Protected Areas Programme

PARKS

Vol 5 No 2 • June 1995

Managing Water Resources

ISSN: 0960-233X

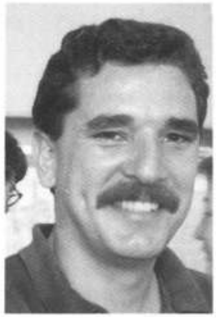
Contents

IUCN
The World Conservation Union

Overview: hydrological management and protected areas

MIKE ACREMAN AND ENRIQUE LAHMANN

Mike Acreman.



Enrique Lahmann.

ALL HUMAN, animal and plant life depends on water. This essential resource is constantly renewed as water circulates through the hydrological cycle. However, the availability of water varies both spatially and temporally. There are areas of the world where precipitation almost never occurs except as occasional dew, such as the Atacama desert in southern Peru. In contrast Tortuguero in Costa Rica frequently receives in the region of 5,000–6,000 mm of rainfall in one year. Precipitation is never constant in any place. In August 1988 only a few years after the tragic scenes of drought and starvation in the Sahel, the world's attention was again drawn to the region, but this time by floods. In Nigeria dams burst and in Sudan the swollen Nile flooded large areas of Khartoum. By the end of the present decade twelve African countries with a total population of approximately 250 million people will suffer severe water stress. With increasing population ten other countries will be similarly stressed by the year 2025. Approximately 1,100 million people, or two-thirds of Africa's population, will then live in these 22 countries, while four (Kenya, Rwanda, Burundi and Malawi) will be facing an extreme water crisis (Falkenmark 1989).

In an effort to secure water resources and to alleviate the human suffering and economic crises caused by floods and droughts, governments and the development assistance community have in recent years invested billions of dollars in building dams, dykes and other river engineering schemes. In northern Nigeria 16 dams have been built on the Hadejia-Jama'are river system alone (van Ketel *et al.* 1987), with the goal of harnessing the river's water for agriculture and urban use. In Asia the preliminary studies of the Flood Action Plan designed to limit Bangladesh's devastating floods are being pursued under the coordination of the World Bank.

The vast majority of this huge international investment is being made in structural approaches to water management; limited attention has been given to the role of natural ecosystems in managing the hydrological cycle and to the potential for improved management of natural aquatic ecosystems and river basins as alternatives to major engineering investments. Furthermore, many of the current investments, notably dams, embankments and river alteration, lead to loss of fisheries and pasture and other forms of ecosystem degradation downstream. This exacerbates the effects of drought and reduces options for meeting the social and economic development needs of the rural poor.

Protected areas have a central role to play in developing new approaches to water management. Upstream ecosystems need to be protected if their vital role in regulating the hydrological cycle is to be maintained. Well managed headwater grasslands and forests reduce runoff during wet periods, increase infiltration to the soil and aquifers and reduce soil erosion. Downstream, protected areas conserve critical areas such as fish nurseries, floodplain forests or pasture, but these must be provided with fresh water and seen as legitimate water users.

To explore these issues further, the IUCN Wetlands Programme held a workshop entitled "Protected Areas and the Hydrological Cycle" at the IV International Congress on Parks and Protected Areas which took place in Caracas, Venezuela, in February 1992. This volume contains a selection of papers from the workshop.

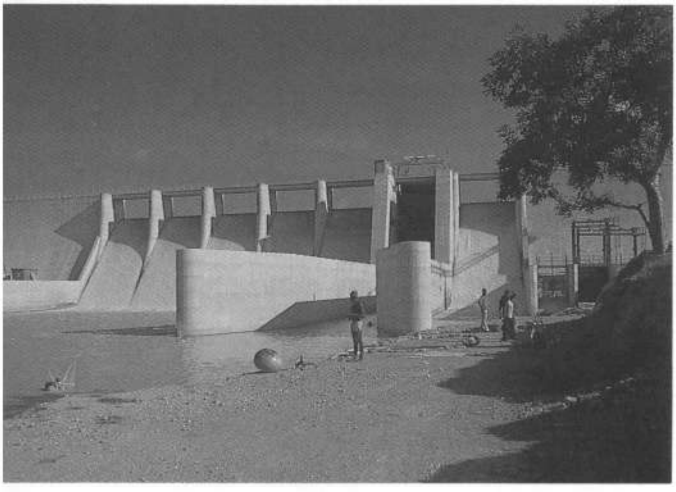
Hydrological functions of natural ecosystems

Natural ecosystems such as forests and wetlands play a valuable role in managing the hydrological cycle. For example, Mackinson (1983) has shown that the cost of establishment of protected areas, reforestation where necessary and other measures to protect the catchments of 11 irrigation projects in Indonesia ranged from less than 1% to 5% of the development costs of the individual irrigation projects. This compares very favourably with the estimated 30–40% loss in efficiency of the irrigation systems if catchments were not properly safeguarded. In Honduras the La Tigra National Park, 7,500 ha of cloud forest, sustains a high quality, well-regulated water flow throughout the year, yielding over 40% of the water supply of Tegucigalpa, the capital city. Because of its value for watershed protection, La Tigra is today the focus of an investment programme involving a series of economic incentives for villagers living in the buffer zones.

The value of utilising the natural functions of aquatic ecosystems, as an alternative to major engineering investments, was recognised as early as 1972 by the US Corps of Army Engineers who recommended that the most cost effective approach to flood control in the Charles River of Massachusetts lay in conserving the 3,800 ha of mainstream wetlands which provide natural valley storage of flood waters.

More recently, Hollis *et al.* (1993) have demonstrated that recharge to the aquifer which supplies well-water to some 100,000 people in the Komodugu-Yobe basin in Nigeria occurs during flooding of the Hadejia-Nguru wetlands upstream. Due to this and knowledge of other functions of the wetland the Nigerian authorities have released water from reservoirs upstream to augment flooding of the wetlands. This is consistent with the ideas of Scudder (1980) and Acreman (1994) who have promoted more widely the benefits of making artificial flood releases from dams to conserve important ecosystems downstream as a cornerstone of integrated river basin management.

The Bakolori Dam, built in the 1970s on the Sokoto River in Nigeria. This dam had significant adverse impacts on downstream ecosystems and indigenous farming systems. Photo: W.M. Adams.



Khan (this volume) describes the important functions of the 75,000 hectare North Selangor Peat Swamp forest, which borders one of the largest rice schemes in Malaysia. These wetlands mitigate floods and maintain high water quality. In recent years the forests have been cleared for agriculture and tin mining, reducing the buffering effect on pollution and releasing sediment. It is forecast that further clearance would result in significant water quality problems in rice schemes.

It is clear from the above examples that conservation of natural ecosystems is essential to maintain their important functions. This can be achieved by a variety of measures from promotion of sustainable use concepts to protection by legislation.

Protected areas as users of freshwater

With increasing population and demand for food and consumer products, the priority for water resources allocation has been given to irrigated agriculture, domestic supply and industry. Occasionally, 'the environment' comes at the bottom of the list without real recognition of the value of natural ecosystems. This was exemplified at a meeting of the riparian states of the Zambezi in 1993 (Matiza *et al.* 1995) when engineers stated that any water passing a proposed dam site was seen as a waste. However, it is clear that valuable coastal wetlands rely on inputs of freshwater. For example, a positive relationship between freshwater runoff and shrimp production was found for the Tortugas grounds off the Florida peninsula of USA by Browder (1985). These estuarine wetlands receive water from the Everglades National Parks and demonstrate the close link between the management of protected areas and energy flows between other natural ecosystems through the hydrological cycle.

Meynell and Qureshi (this volume) report on the functions and products of the Indus delta in Pakistan which has been proposed as a National Park. This mangrove ecosystem provides valuable protection for Port Qasim, nursery grounds for fish, fodder for animals and fuelwood for cooking. However, the delta relies on inputs of freshwater and sediment from the Indus river, both of which have been reduced drastically by construction of dams and irrigation schemes upstream, leading to increased salinity and degradation of the delta. These findings reinforce earlier studies by Snedaker and Jugo (1974) who undertook a global assessment of mangrove forests worldwide and found that the complexity and productivity of coastal wetlands increases with high freshwater availability.

The delta of the River Senegal in West Africa contains three important protected areas: the Diawling National Park in Mauritania and the Djoudj Birds National Park and Ndiael Reserve in Senegal. The lower reaches of the river traditionally experienced episodes of high salinity during the dry season and freshwater flooding during the wet season. However, the river has been dammed in its headwater to regulate in-flows and at its mouth to stop salt intrusion and to maintain water levels for irrigation. Vincke and Thiaw (this volume) argue that the future of these Parks depends upon the political will to balance the conflicting needs for the control of water quality and quantity between irrigation and the protected areas.

In central Africa, Tchamba, Drijver and Njiforti (this volume) show that management of the Logone River in northern Cameroon, for the development of intensive rice irrigation, has contributed to the degradation, loss of biodiversity and reduced tourist potential of Waza National Park, on the river's floodplain. In addition the floodplain fisheries and pastoral economy in the buffer zone were devastated. To rectify this situation, the embankments along the river were modified in 1994 to allow flood waters to reach the floodplain, which will hopefully revitalise the Park and its surrounds (Wesseling *et al.* 1995). Adams (this volume) argues that while large scale dams and other technological approaches to water management may be in conflict with protected areas, traditional water management at community level is compatible with protected area management, especially in the buffer zones.

Dams may not always be environmentally detrimental. Masundire (1995) reported that Lake Kariba, created by the construction of Kariba dam, supports an important inland fishery and the whole shoreline has been declared a 'recreational park' as the availability of water during the dry season attracts large herds of buffalo, eland and other species. However, the dam has had negative effects on the ecology downstream and on the health of local people as disease vectors such as snails have proliferated.

The above examples demonstrate that protected areas cannot be protected in isolation. If a protected area relies on freshwater, the river basin above must be managed in a way which treats the area as a legitimate water user so that supplies are maintained.

Indirect effects on protected areas

Exploitation and management of the hydrological cycle may have serious indirect effects on protected areas not recognised during planning. For example, a dam is about to be built, funded by the World Bank, at the Kapuchira falls on the River Shire in Malawi to generate hydro-electric power. The most obvious effect will be on the Elephant marsh downstream, which Malawi was intending to designate as a Ramsar site. However, of even greater concern is the siting of the construction camp within the Lengwe National Park, which is likely to lead to poaching and cutting of trees by the construction workers.

The valley of the Arun River in eastern Nepal is an area of high ecological diversity and many isolated human cultures. Environmental studies have shown that the proposed Arun III hydro-electric power project, which is a run-of-the-river scheme, will have only minor impacts. However, major problems will result from construction of the access road, which will cut through undisturbed forests allowing exploitation of resources and exposure of people to outside influences.

Conclusions

From California to Bangkok and India to Honduras, the limited availability of clean, fresh water is now seen as a major constraint to further social and economic development. In the Middle East many commentators argue that if there is to be a new regional conflict its catalyst will be the need for fresh water. In responding to this growing crisis, *Caring for the Earth* (IUCN/UNEP/WWF 1991) has called for "better awareness of how the water cycle works, the effect of land uses on the water cycle, the importance of wetlands and other key ecosystems and of how to use water and aquatic resources sustainably". This was reinforced in the Dublin statement (ICWE 1992) which states that "since water sustains all life, effective management of water resources demands a holistic approach, linking social and economic development with protection of natural ecosystems".

"Effective management of water resources demands a holistic approach, linking social and economic development with protection of natural ecosystems." Photo: P.-J. Meynell.

Thus, there is growing recognition of the need to develop a more broad-based approach to water management, with greater emphasis given to the drainage basin as the unit, effective integrated management of these basins and conservation of critical habitats with important hydrological functions. Furthermore, protected areas are one of the most valuable management options available and can serve as catalysts for environmentally sound management over a wider area. To achieve this, however, protected area managers will need to build collaborative links with hydrologists, hydraulic engineers and water resource planners. In addition, governments and the development assistance community will need to appreciate and invest in protected area management as an integral component of water resource development, and recognise the role that a well managed hydrological regime can play in supporting productive natural ecosystems downstream.

Protected areas need to be seen as part of the solution to river basin management. In most areas they will cover only a relatively small proportion of the entire basin. However, by maintaining natural vegetation cover and fulfilling a range of protective ecosystem functions, they can serve as focal points for further investment in sound land management and economic investment in the buffer zones and the wider basin.

References

Acreman, M.C. 1994. The role of artificial flooding in integrated development of river basins in Africa. In: Kirby, C., and White, W.R. (eds.) *Integrated river basin development*. Wiley.

Browder, J. 1985. An estimate of the value of mangroves to the economy, based on net primary productivity.

Falkenmark, M. 1989. The massive water scarcity now threatening Africa: why isn't it being addressed? *Ambio*, 18, 2.

Hollis, G.E., Adams, W.M., and Aminu-Kano, M. 1993. *The Hadejia-Nguru Wetlands: Environment, economy and sustainable development of a Sahelian floodplain wetland*. IUCN, Gland, Switzerland.

ICWE (International Conference on Water and the Environment). 1992. *The Dublin Statement and report of the Conference*. 26–31 January 1992. World Meteorological Organization.

IUCN/UNEP/WWF. 1991. *Caring for the Earth – A Strategy for Sustainable Living*. Gland, Switzerland.

Mackinson, J.R. 1983. Irrigation and watershed protection in Indonesia. Report to the World Bank.

Masundire, H.M. 1995. The effects of Kariba gorge dam and its management on the people and ecology of the Zambezi valley. In Acreman, M.C., and Hollis, G.E. *Hydrological management and wetlands in sub-Saharan Africa*. IUCN.

Matiza, T., Crafter, S., and Dale, P. 1995. *Water resources use in the Zambezi basin*. Proceedings of a workshop held at Kasane, Botswana. IUCN, Gland, Switzerland.

Scudder, T. 1980. River basin development and local initiative in African Savanna environments. In: Harris, D.R. (ed.) *Human ecology in savanna environments*. Academic Press, London.

Snedaker, S.C., and Jugo, A.E. 1974. The role of mangrove ecosystems in the maintenance of environmental quality and a high productivity of desirable fishes. Bur. Sports Fisheries and Wildlife, Washington DC. 381 pp.

Van Ketel, A., *et al.* 1987. West Africa Review – a comprehensive listing of water management projects and an outline of their effects on wetlands.

Wesseling, J.W., Noah, E., and Drijver, C.A. 1995. Rehabilitation of the Logone floodplain, Cameroon, through hydrological management. In: Acreman, M.C., and Hollis, G.E. (eds.) *Hydrological management and wetlands in sub-Saharan Africa*. IUCN, Switzerland.

Mike Acreman, Freshwater Management Adviser, IUCN – The World Conservation Union, Rue Mauverney 28, 1196 Gland, Switzerland.

Enrique Lahmann, Regional Representative, IUCN Regional Office for Central America, Apartado Postal 0146, 2150 Moravia, Costa Rica.

The impact of flood reduction in and around the Waza National Park, Cameroon

M.N. TCHAMBA, C.A. DRIJVER AND H. NJIFORTI

Approximately 6,000 km² of the natural floodplain of the Logone River in North Cameroon constitutes an important sahelian wetland ecosystem. Part of the floodplain is protected as a national park and contains populations of elephants, giraffes and lions and a rich and varied avifauna. The floodplain is a life-supporting system for traditional human communities which depend on natural inundation to sustain their cattle, fisheries, floating rice and recession agriculture. Especially in the dry season its fresh pastures are essential for the survival of large numbers of cattle.

In recent years the environment of the Logone floodplain has changed considerably. The growing numbers of people and cattle combined with the sequence of recent droughts and the creation of large-scale rice projects have led to resource degradation and environmental problems.

The reduced depth of inundation has led to a dying off of floodplain grasslands with consequences for wildlife and cattle productivity. Also fishing and traditional floating rice culture have been severely affected. Crop damage by elephants and forest degradation have increased. During dry years (since 1985) human lives have had to be saved by migration and food aid. Over-exploitation has resulted in further degradation.

The hydrological rehabilitation of the Logone floodplain has been studied by the Waza Logone Project. On the basis of present knowledge possible measures are: opening of the Logone embankment in order to reconnect the floodplain with the Logone river; the controlled release of water from Lake Maga combined with increased flow from the Logone to Lake Maga; and possibly the rehabilitation of creeks and canals that used to transport water onto the plain.

THE APPROXIMATELY 6,000 km² of natural floodplain of the Logone river in the North Cameroon is an important sahelian wetland ecosystem. The floodplain, known locally as yaérés, is a life-supporting system for traditional human communities which depend on natural inundation to sustain their cattle, fisheries, floating rice and recession agriculture. Especially in the dry season its fresh pastures are essential for the survival of large numbers of wildlife and cattle.

In recent years the environment of the yaérés has changed considerably. The growing numbers of people and cattle combined with the sequence of recent droughts and the creation of large-scale rice projects have led to resource degradation and environmental problems.

Since 1972 the Sahelo-Soudanian zone has experienced a significant reduction in rainfall and river floods which have reduced the inundation in the Waza Logone region. In 1979 the "Société d'Expansion et de Modernisation de la Riziculture de Yagoua" (SEMRY II) constructed a dam between Pouss and Guirvidig (Figure 1). Behind the dam in Lake Maga some 0.2 km³ of water can be stored for irrigation of the cultivated area downstream of the dam. In addition, on the left bank of the

Logone, an embankment has been constructed between Yagoua and Tékélé (Figure 1) in order to prevent flooding of the rice fields from the Logone river.

The reduced depth of inundation has led to a dying off of floodplain grasslands with a consequential decline in wildlife and cattle. Furthermore fishing and traditional floating rice culture is also severely affected. Crop damage by elephants and forest degradation have increased. Since 1985 droughts have resulted in migration and food aid for those who remained. Over-exploitation has resulted in further degradation of resources.

This paper examines some of the problems related to reduced flooding in the Waza Logone region and especially the Waza National Park. The problems discussed have been identified on the basis of hydrological studies conducted by the Institute of Zootechnical Research (IRZ, Cameroon), the Centre for Environmental Studies and Development in Cameroon (CEDC), and the Centre for Environmental Studies (CML, Netherlands).

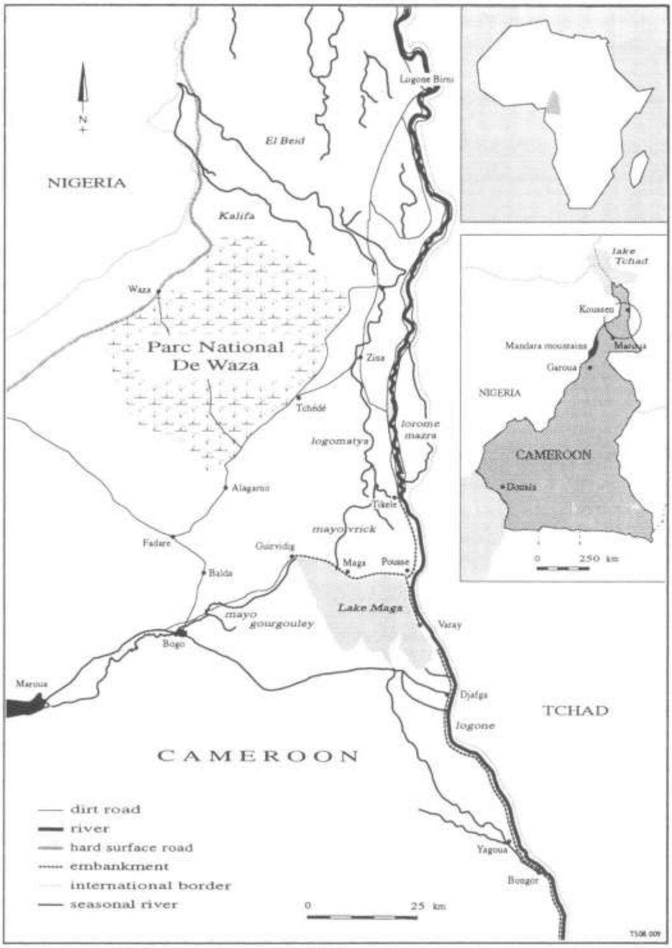


Figure 1. Waza Logone Project Region.

Description of Waza National Park and its surroundings

Some 150,000 ha of the Logone floodplain was designated as a National Park in 1968, having been a Forest and Faunal Reserve since 1934.

The Park lies within the Chad Basin at an altitude of 300–320 m. Its landscape is flat and most of it used to be inundated for part of the year directly from rainwater and by floodwater from the Logone river. The seasonal inundation of Waza has profound implications for the Park's ecology.

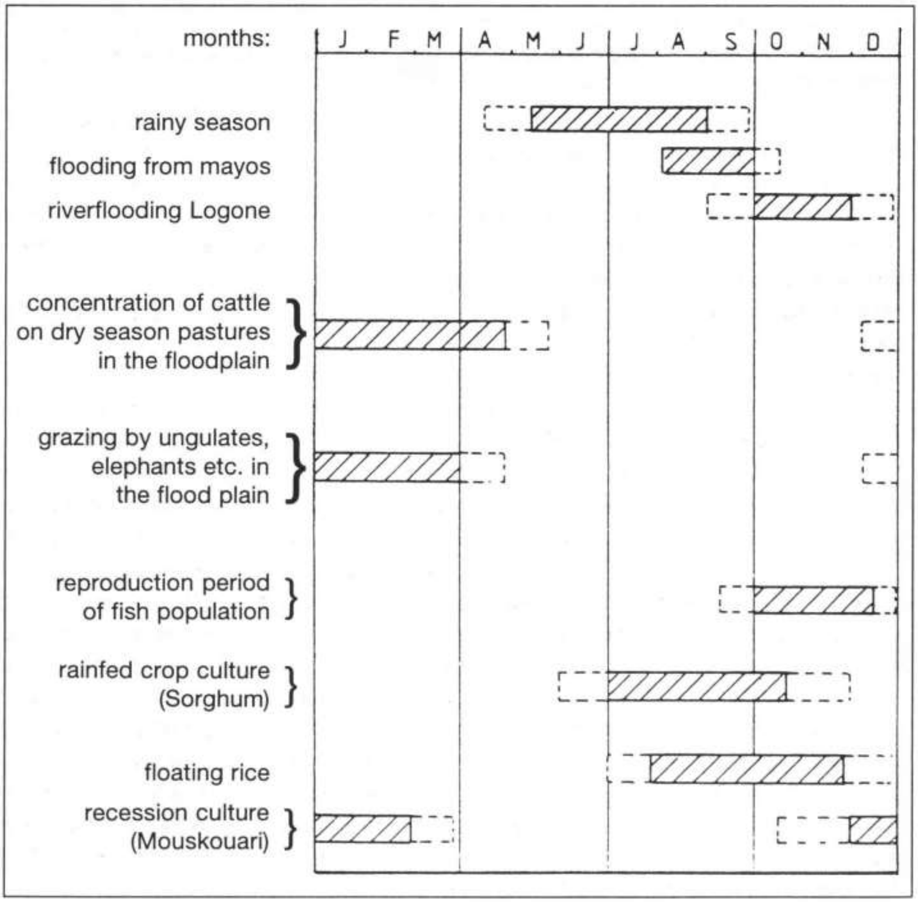
Waza is divided naturally into three ecological zones. The eastern portion, comprising about half of the park, is the floodplain zone, which is an extensive open grassy plain dominated by *Vetiveria nigrita*, *Oryza barthii*, *Echinochloa pyramidalis* and *Echinochloa stagnina*. The soils are heavy clay and the zone is inundated for up to six months in wet years. The western half is slightly raised above the level of the floodplain and comprises two sectors. In the north flooding is more local and results primarily from direct rainfall, allowing the development of open forest of sahel type dominated by *Acacia seyal*. The herbaceous layer is dominated by *Sorghum aethiopicum*. In contrast the southern area is never inundated. This sector is covered by *Anogeissus leiocarpus*, *Bauhinia refucens* and *Tamarindus indica* and the soils are sandy.

Waza National Park is the only area in the Sahelo-Soudanian zone of Africa where a great variety of wildlife can still be found, including giraffe *Giraffa camelopardalis*, elephant *Loxodonta africana*, lion *Panthera leo*, hyena *Hyena hyena*, jackal *Canus aureus*, kob topi *Damaliscus korrigum*, roan antelope *Hippotragus equinus*, and red-fronted gazelle *Gazella rufifrons*. The rich and very varied avifauna comprises ostrich *Struthio camelus*, marabou stork *Leptoptilos crumeniferus*, bateleur *Terathopius ecaudatus*, secretary bird *Sagittarius serpentarius*, ground hornbill *Bucorvus abyssinicus,* guinea fowl *Numida meleagris* etc., and migratory species which pass the European winter in the wetlands of the Sahel.

The distribution of game in the Park is very largely determined by two factors: seasonal inundation and the availability of water during the dry season. In particular the rich pastures provide an important food source for elephant and kob, and as the flood waters recede in the dry season these and other species move on to the floodplain. The floodplain is also of major importance for waterfowl during the annual flood.

Human use of the floodplain is also controlled by the annual cycle of rainfall and river flood (Figure 2). Rainfed agricultural is practised on the surrounding uplands, while floating rice is planted as the floodwaters rise and recession agriculture is practised on the floodplain as the floodwaters recede. Fish move on to the floodplain

Figure 2. *The interrelation between climate, hydrological cycle and human exploitation of the Logone floodplain environment.* Source: Drijver and Schrader 1998.



with the flood and, following breeding and growth, fish are harvested as water starts draining back to the main channels. Cabot (1965) identified the Logone floodplain as having one of the most productive fisheries in Africa.

Some 200,000–300,000 head of cattle and tens of thousands of sheep and goats spend the long dry season in the floodplain each year. The cattle move on to the floodplain pastures as the flood recedes, at which time the surrounding savanna pastures are already withered, and their protein content has declined. The yaéré thus plays a critical role in cattle production in the region, providing a dry season food resource without which the total cattle carrying capacity of the region would be significantly lower. The carrying capacity of the yaéré is estimated as 1–2 cattle per hectare, whereas in the surrounding savanna it is estimated as 0.2 per hectare (Broer and Tejiogho 1988).

Hydrological functioning of the floodplain

The Logone River rises on the Adamaoua Plateau, some 700 km south of Lake Chad. Flowing north, the Logone joins the Chari near Kousseri (Figure 1) shortly before the latter enters Lake Chad. The mechanism of flooding consists of three stages:

1. At the beginning of the rainy season (June–July), local precipitation causes saturation of the subsoil. Cracks that were formed during the dry season disappear and the soil becomes impermeable.
2. Through the combined effect of local rainfall and water from several tributaries called "mayos" descending from the Mandara Mountains, the floodplain south of Waza is first inundated.
3. In the months of September and October, as the discharge of the Logone river reaches its maximum, in wet and medium wet years most of the plain is flooded. From October onwards the area drains slowly in a north-easterly direction. The Logone then extends over a floodplain of 6,000 km^2. The depth of water over the floodplain (up to 1.2 m) and the duration of the flood (three months on average) are variable, depending on rainfall in the catchment area.

A hydrological study carried out by Delft Hydraulics in 1983 (Waterloopkundig Laboratorium 1983) points out that the reduced inundation in the Waza Logone floodplain is caused by a combination of factors :

- reduced discharge of the Logone river and the mayos from the Mandara Mountains.
- hydrological impacts of SEMRY II.

In the absence of quantitative data, it is difficult to determine the relative importance of each factor. Available data give the impression that the contribution of SEMRY is the smaller one (between 20 and 40%). However, the effect of SEMRY is a permanent one, and is additional to the effect of reduced flows in dry years. An analysis of floodlines and discharge of the Logone shows that the embankments constructed by SEMRY for water management have their largest influence during average and dry years (Project Waza Logone 1988). During extremely wet years the hydrological impact of SEMRY is small in relation to the large quantities of water provided by the Logone. During extremely dry years (e.g. 1984) SEMRY's impact on flooding is limited because even without SEMRY hardly any inundation would occur. Since 1972 dry and extreme dry years have occurred more frequently than before in the Sahelo-Soudanian zone. Before 1972 the perennial grasses in the floodplain could survive because there was sufficient flooding in the majority of years. After 1972 the process of degradation had started.

Whether or not SEMRY is the major factor causing environmental problems, SEMRY's water management programme is a key-factor in determining whether the environmental problems will continue to exist.

Analysis of environmental problems

Decline of floodplain fish populations

According to Van der Zee (1987), the productivity of the floodplain fishery is directly related to the depth and duration of the annual river flood inundation. If this is less than 50 cm in depth, or shorter than one month, fish reproduction is low. Since 1972, these conditions have occurred regularly on the floodplain of the Logone, and have led to both the disappearance of several fish species, and to a decline in the size of catches. This has had dramatic consequences for the 4,000–5,000 people of the Kotoko tribe and 1,000 Mousgoum who rely upon these resources. In villages along the border of Waza National Park catches have fallen to less than 10% of former values, with the result that many families have left these villages to fish elsewhere. Some have settled near the Logomatya, leading to over-exploitation of these resources and conflict with the populations resident there. More intensive fishing techniques and the absence of controls on mesh size have added to the problem and contributed to an increase in pressure upon the fish populations. Now, even with rehabilitation of the river flood, effective control measures need to be implemented if over-exploitation of this diminished resource is to be prevented.

In response to the declining fish catches, agricultural activities are expanding among the Kotoko. Millet, vegetables, fruit trees and irrigated rice are now being explored. However, most people lack the money to invest in these alternative activities, most of which are in any case considered to be secondary.

Disappearance of floating rice culture

On the floodplain, floating rice was cultivated by the Kotoko for local consumption. Three varieties were planted, each one adapted to different conditions. During years of good flood, many Kotoko villages were self-sufficient in rice, but since 1982 no floating rice has been successfully cultivated over much of the floodplain. As a result people have turned to cultivation of millet and to buying rice from SEMRY II.

Degradation of floodplain pastures

Over the past three years two species of perennial grass which depend upon regular flooding, *Echinochloa pyramidalis* and *Vetiveria nigritana*, have disappeared over large areas of the floodplain; where they still occur they show a decreased growth (Brummelen and Specken 1986). The areas where pastures remain productive, between the Logomatya and the Logone, are those which have received a limited flood. Those on the west of the floodplain, in particular the pastures of Waza National Park, have suffered most from the reduced flood. In total, an area of 1,500 km^2 of pasture has been lost. Of this, 600 km^2 are within Waza National Park.

Loss of these floodplain pastures has had serious consequences for both wildlife and cattle. Only the perennial floodplain grasses produce a regrowth after grazing, even late in the dry season. In contrast, the surrounding rain-fed savanna is covered with annual grasses which die at the beginning of the dry season. Late grazers like wildlife and cattle therefore depend on the regrowth of perennial grasses for their survival during the dry season.

Decline of wildlife

Several factors have played a role in the decline of wildlife in Waza National Park and its surroundings. Increasing human population numbers and introduction of modern weapons are the main causes for disappearance of wildlife outside the Waza National Park. Commercial poaching for markets in Cameroon and Nigeria is a common phenomenon in Waza. The reduction in flooding has increased poaching since the park is accessible for most of the year. Inundation used to give natural protection to floodplain grazers.

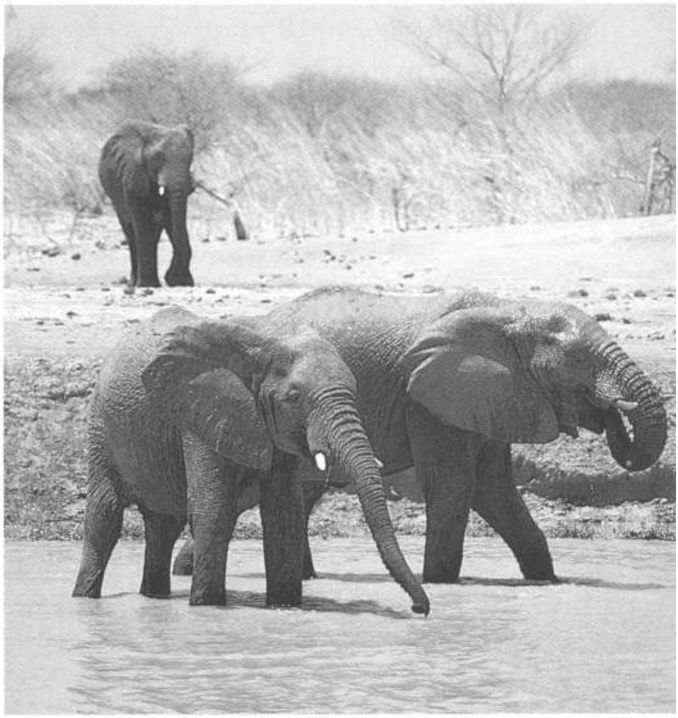
The kob antelope is a typical example of wildlife decline in Waza. From 30,000 individuals in 1968, its population had fallen to less than 2,000 in 1988 (Korthof 1988). The lack of inundation is not the only reason for this decline. Other factors are the occurrence of rinderpest in 1983 and the growing percentage of kob killed by lions and poachers.

The Defassa waterbuck *Kobus defassa* and Bohor reedbuck *Redunca redunca* have disappeared completely. The elephant is the only species that is increasing in number in the area.

Crop damage by elephant

Waza National Park is the core area for about 1,100 elephants (Tchamba 1991). Recent studies (Steehouwer and Kouahou 1988) have shown that damage by elephants is restricted to specific areas bordering the park and along migration routes, but for individual farmers in these areas the damage by elephants can be very serious (US $50–$850). Among the factors which have contributed to increased crop damage in recent years, three are of particular importance:

- One of the major food sources in the Park, the *Vetiveria* floodplain pastures, has largely disappeared as a result of the reduced river floods. The elephants, therefore, are obliged to search more widely for food resources.
- The number of elephants has increased as a result of immigration from Chad.
- As environmental conditions around the Park have deteriorated and local communities have shifted from cattle herding and fishing to agriculture, migration zones outside of the park are being encroached upon by agricultural fields.



In some parts of the Logone floodplain elephants cause significant damage to crops. Photo: M. Acreman.

Degradation of forests and trees

Okula and Size (1986) indicated that elephant damage to *Acacia* trees in Waza National Park was not serious enough to warrant management interference. Tchamba and Mahamat (1991) studied the impact of elephant browsing on the vegetation in Kalamaloue National Park (100 km north of Waza) and concluded that elephant browsing significantly interferes with natural regeneration of trees. Apart from these studies no systematic data exist about the condition of trees and forests in the region.

Field impressions indicate that in the forest zone in and outside the Waza Park many trees are dying (e.g. *Anogeissus* and *Sclerocarya*); the cause here is not over-exploitation by elephants but desiccation due to a lowering of the groundwater level.

Decreasing carrying capacity for cattle

The loss of 900 km^2 of floodplain pastures outside of the Waza Park represents a decrease in theoretical carrying capacity of 100,000–150,000 animals, worth CFA 700 million per year (Broer and Tejiogho 1988). These figures summarise what is an extremely complex picture. Thus while some pastoralists now graze their cattle elsewhere, others have been forced by drought to increase use of the floodplain. For example, in 1985 the Arab Choa, who normally stay north of the project area, came to the floodplain. Similarly the semi-nomadic Ngara-En, who traditionally used the western part of the floodplain which has suffered most from drought, stayed longer on the rain-fed pastures of the Diamaré to the south and used only parts of the floodplain close to the Logone. This resulted in higher grazing pressure on these remaining areas and precipitated conflicts over grazing rights.

Grazing intensities on the floodplain have also increased by the appearance of large herds owned by wealthy individuals from the urban centres and for whom cattle serve as a means of commercial investment. Under these conditions, where cattle are seen as a means of generating income, the incentive for sustainable utilisation of the pasture, and associated controls on herd size, is no longer present.

Hydrological rehabilitation of the floodplain

Very few efforts have been made by government services or regional projects to rehabilitate the floodplain. An exception is a local initiative at Iviye where a small dam has been constructed in the Logomatya to provide water to a pasture area during the dry years (Figure 1). In Tékelé the local Development Committee has made a request to the subdivisional officer to open the embankment in order to allow flooding of their pastures.

The hydrological rehabilitation of the floodplain is under study by the IUCN Waza Logone Project. On the basis of present knowledge it is possible to indicate four potential measures.

Opening of the Logone embankment near Tékélé

Just north of Tékélé the Mayo Petit Goroma used to be the main intake of the Logomatya. Like the Mayo Areitekele, the entrance is blocked by the SEMRY embankment between Pousse and Tékélé. However, the bed of the Petit Goroma has a sufficient gradient and meets the Mayo Vrick at a sufficiently low elevation to avoid backwater effects that may interfere with the drainage of the Pousse rice fields. The capacity of the present channel of the Goroma is estimated at some 15 m^{3}sec^{-1}.

The rehabilitation measure would be to open the connection between the Petit Goroma and the Logone. If a discharge of more than 15 $m^3 sec^{-1}$ is desired some excavation would be required to increase the capacity of the Goroma, and protection of the road by construction of a spillway may have to be considered.

Maximum release of water from Lake Maga and the Logone

In most years Lake Maga has sufficient surplus water which, if released, could provide substantial flooding over much of the floodplain. The existing sluice-gates in the Maga dam permit the release of water through the Mayo Vrick and the associated natural network of channels and depressions. Other possibilities for maximising release of water are the re-opening of the Mayo Gorouma near Tékélé and the re-activation of the Mayo Tsanaga near Guirvidig. Accordingly the Waza Logone Project will study the feasibility of hydrological rehabilitation of the floodplain through these channels and, if this is feasible, prepare a plan for rehabilitation, oversee its implementation, and establish a system to monitor the impact of controlled flooding upon the natural resources of the floodplain and the communities dependent upon these.

Efficient use of available water in the floodplain

Water flows towards the floodplain through natural channels. The rate of flow could be increased by dredging the channels. Removal of certain high ridges on the bed of the river Logomatya could also increase the rate of flow towards the floodplain. Many small canals, like that dug at Talengourou/Talabal in 1982, could be made.

During the filling up of the Logomatya by water from the Logone, a good quantity of the water flows back into the Logone. This water could be held back by building a number of small dams on the Logomatya. This would increase the quantity of water going into the floodplain by eliminating backflow into the Logone.

Another way by which the inundations could be affected independently of the water level in the Logone is the construction of a canal from Maga or Guividig to Diéguеré (Figure 1). Water for this canal will be obtained from the Lake during water release.

Deepening of waterholes for wildlife

Another human intervention to try to reduce the impact of the reduced inundations could be the deepening of waterholes which already exist but which, through the years, have been partially filled with clay deposited by the running waters from heavy rains. However, this is difficult to plan and execute since the waterholes' shape plays a substantial role in providing habitats for the aquatic vegetation and therefore for the avifauna, a very important element for Waza National Park.

Digging of new waterholes in the park should be very carefully planned since the vegetation is seriously damaged around existing waterholes.

Conclusion

The reduction of inundations is the major cause for the decrease of fish production, floating rice culture, pasture condition and livestock production. Moreover it is a contributing factor to the decline of wildlife and the occurrence of crop damage by elephants. Therefore the hydrological rehabilitation of the floodplain is a prerequisite for further actions at the regional or local level.

The full benefits of long-term rehabilitation of the Logone floodplain will only be realised if the water resources are managed in recognition of the requirements of the distinct user groups. These include the SEMRY rice project, the downstream production systems and Waza National Park. One of the main lines of action for the Waza Logone Project is the hydrological rehabilitation of the floodplain. Given the interest and motivation of the local population to participate in actions that may lead to a rehabilitation of the floodplain resources, the Waza Logone Project should pay special attention to local initiatives. These local initiatives will need to be coordinated in order to prevent conflicts between user groups and further environmental problems.

References

Broer, W., and Tejiogho. 1988. *La capacité de charge des "yaérés" au Nord du Cameroun.* Leiden, CML. Student report.

Brummelen, T. van, and Specken, B. 1986. *La végétation des yaérés du Parc National de Waza.* Cameroun. Leiden, CML. Student report.

Cabot, J. 1965. *Le bassin du moyen Logone.* Paris. ORSTOM.

Drijver, C.A., and Schrader, T.H. 1988. *Towards an integrated approach to poverty and environmental degradation in the Third World - the example of the Logone floodplain in North Cameroon.* CML, Leiden.

Korthof, H. 1988. *Le Cob de Buffon dans le Parc National de Waza, Cameroun.* Unpublished manuscript.

Okula, J.P., and Size, W.R. 1986. Effects of elephant browsing on *Acacia seyal* in Waza National Park, Cameroon. *Afr. J. Ecol.*, 24: 1–6.

Project Waza Logone. 1988. *Conservation and Development in the Waza Logone region, Republic of Cameroon.* Project Document. Leiden, CML.

Steehouwer, G., and Kouahou, E. 1988. *Olifanten, milieuveranderigen en gebiedsin richting. De olifanten van de Logone-yaérés in Noord Kameroen.* CML, Leiden. Student report.

Tchamba, M.N. 1991. *Status and trends of some large mammals and ostrich in Waza National Park, Cameroon.*

Tchamba, M.N., and Mahamat, H. 1991. Effects of elephant browsing on the vegetation in Kalamaloué National Park, Cameroon. *Mammalia* 56 (4): 533–540.

Waterloopkundig Laboratorium (Laboratoire d'Hydraulique de Delft). 1983. *Le problème du manque d'eau dans le Parc National de Waza au Nord du Cameroon.* Delft.

Zee, E. van der. 1987. *Les pêcheurs Kotoko dans les 'yaérés' du Logone. CML, Leiden.* Student report.

M.N. Tchamba and H. Njiforti: Centre for Environmental Studies and Development in Cameroon, PO Box 410 Maroua, Cameroon.

Carel Drijver: WWF Netherlands, Boulevard 12, PO Box 7, Zeist, Netherlands.

Water resource management in the Indus river delta, Pakistan

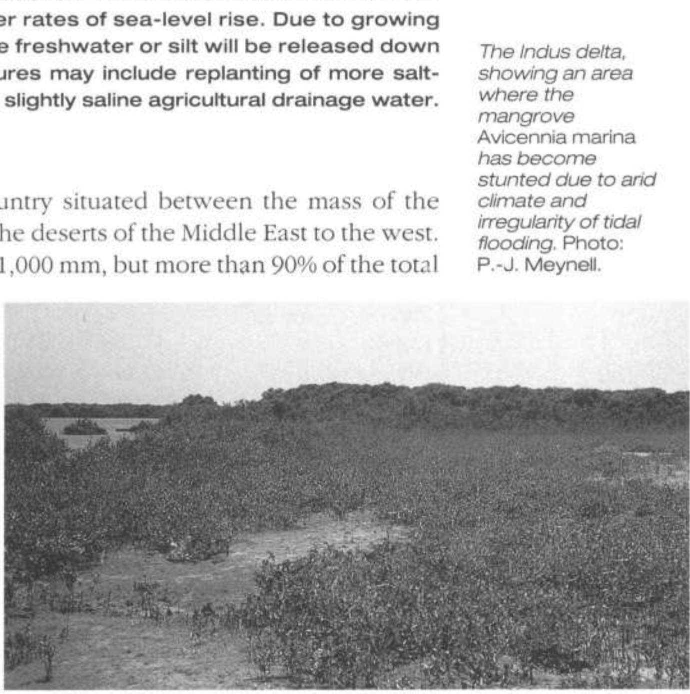
PETER-JOHN MEYNELL AND M. TAHIR QURESHI

Over the past 40 years, the Indus river has been dammed progressively and diverted for irrigation, electricity generation and domestic and industrial water supply. The original average annual flow in the Indus was about 190 billion m³ (150 MAF [million acre feet]), from which about 130 billion m³ (105 MAF) are currently abstracted each year, and about 40 billion m³ (35 MAF) are released from the lowest barrage on the river. Only about 25 billion m³ (20 MAF) reaches the delta and for nine months of the year no freshwater flows out at all. Recent water apportionment agreements between the provinces of Pakistan have recognised that a minimum of 10 MAF should be discharged into the delta for environmental reasons. Irrigation without adequate drainage has resulted in the loss of agricultural lands due to waterlogging and hypersaline soils. About half the water diverted for irrigation is lost before it reaches the fields due to seepage, evaporation and inefficiencies in the system. Saline intrusion into groundwater from the delta is becoming a serious problem in the lower Indus. Progressive reduction of the freshwater flows has an effect upon the salinities in the delta creeks (often salinities exceed 45 ppt [parts per thousand]). This puts stress upon mangroves causing stunting and loss of seedlings. The survival of the mangrove ecosystem is at risk.

In addition, the reduction in silt discharge, from 400 million tonnes per year to less than 100 million tonnes at present and probably lower in the future, has implications for the geomorphology of the delta. When coupled with increased sea-level rise, it is probable that the delta will flatten and erode and provide less coastal protection against south-west monsoon forces. The reduction in land-based sediment will mean that the mangroves cannot cope with higher rates of sea-level rise. Due to growing population pressures, it is unlikely that more freshwater or silt will be released down the Indus in the future. Management measures may include replanting of more salt-tolerant mangrove species and discharge of slightly saline agricultural drainage water.

PAKISTAN is an arid or semi-arid country situated between the mass of the Indian sub-continent to the east and the deserts of the Middle East to the west. Mean annual rainfall varies from about 50–1,000 mm, but more than 90% of the total land area (88.2 million hectares) receives less than 500 mm of rainfall each year. About 75% of the total rain falls during three months of the year (July, August and September).

The most important geographical feature of Pakistan is the river Indus and its tributaries (Kabul, Jhelum and Chenab), which rise high in the Karakorum and western Himalaya mountains. The Indus flows through the foothills and agricultural plains of Punjab and Sindh to the Indus delta and the Arabian Sea.



The Indus delta, showing an area where the mangrove Avicennia marina *has become stunted due to arid climate and irregularity of tidal flooding.* Photo: P.-J. Meynell.

The Indus delta occupies an area of some 600,000 hectares, of which 240,000 hectares are covered with mangroves. The Indus is one of the world's major rivers, with a combined average annual flow of about 200 billion m^3 (159 MAF), deriving most of its flow from the melt water of glaciers in the high mountains. Over the last 100 years the Indus river system has been progressively dammed for water storage and hydropower and diverted by barrages for one of the most extensive irrigation systems in the world. However, it is now becoming clear that the system is approaching the limits of water exploitation and that this exploitation has had considerable environmental costs. It is also clear that given the rising population of Pakistan (about 3.5% rise per year from the recent estimate of 110 million, projected to top 200 million by 2025), the pressure on water resources will intensify. This paper considers the effects of water diversion upon critical areas, especially the mangrove creeks of the Indus delta, where until recently any freshwater reaching the sea has been considered as wasted by the decision makers.

Table 1. *Inflows of Indus and eastern river system.*

Source	Kharif		Rabi		Annual	
	billion m^3	MAF	billion m^3	MAF	billion m^3	MAF
A. MEAN INFLOWS						
Rim Stations						
Indus	65.24	52.89	10.07	8.16	75.31	61.05
Jhelum	21.82	17.69	5.45	4.42	27.27	22.11
Chenab	25.40	20.59	4.80	3.89	30.20	24.48
Swat/Kabul	22.15	17.96	4.29	3.48	26.45	21.44
Haro/Soan	1.48	1.20	0.36	0.29	1.84	1.49
Ravi/Sutlej	8.51	6.90	1.50	1.22	10.02	8.12
Direct Inflow						
Eastern Rivers	2.41	1.95	0.17	0.14	2.58	2.09
Swat/Kabul	3.69	2.99	1.42	1.15	5.11	4.14
Tarbela to Taunsa	1.99	1.61	0.63	0.51	2.62	2.12
Total Inflows	**152.68**	**123.78**	**28.69**	**23.26**	**181.37**	**147.04**
B. 80% PROBABILITY FLOWS						
Rim Stations						
Indus	54.47	44.16	8.92	7.23	63.39	51.39
Jhelum	16.97	13.76	4.11	3.33	21.08	17.00
Chenab	21.23	17.21	3.61	2.93	24.84	20.14
Swat/Kabul	17.48	14.17	3.40	2.76	20.88	16.93
Haro/Soan	0.78	0.63	0.26	0.21	1.04	0.84
Ravi/Sutlej	3.55	2.88	0.73	0.59	4.28	3.47
Direct Inflow						
Eastern Rivers	2.12	1.72	0.12	2.24	0.10	1.82
Swat/Kabul	1.39	1.13	0.73	2.12	0.59	1.72
Tarbela to Taunasa	1.20	0.97	0.43	1.63	0.35	1.32
Total Inflows	**119.19**	**96.63**	**22.31**	**141.51**	**18.09**	**114.72**

Period of record: Indus 1936–1988; Jhelum, Chenab 1922–1988; Ravi, Sutlej 1966–1988; others 1966–1976. Source: Environment Operations and Strategy Division, Guide to the Indus Basin Model Revised, January 1990, The World Bank.

Flows and water use in the Indus river system

The annual average flows of the river Indus and its tributaries total 181 billion m^3 (147 MAF) as shown in Table 1. The eastern rivers of Chenab, Ravi and Sutlej are under the control of India (as agreed between India and Pakistan in the 1950s). Pakistan can thus only rely on the flows from the western rivers, although in practice some water is let through by India, but not always at a convenient time.

At the time of independence, the irrigation system consisted of old-established canal systems dependent on the run-of-river flows of the Indus and there were no dams to store surplus supplies for future use. After independence, extensive water development programmes were undertaken to ensure regular and ample supply of water. The present irrigation scheme consists of three storage reservoirs at Tarbela, Mangla and Chashma, 16 barrages, 12 inter-river link canals, two siphons and 43 main canals. The total length of canals is about 56,000 km, with 88,000 farm outlets. There are about 1.6 million km of farm channels and water courses.

The total irrigated area (Culturable Command Area, CCA) in the Indus Plain covers 12 million hectares irrigated by canals from the river, 4 million hectares from tubewells and other sources. Figure 1 shows the extent of the CCA.

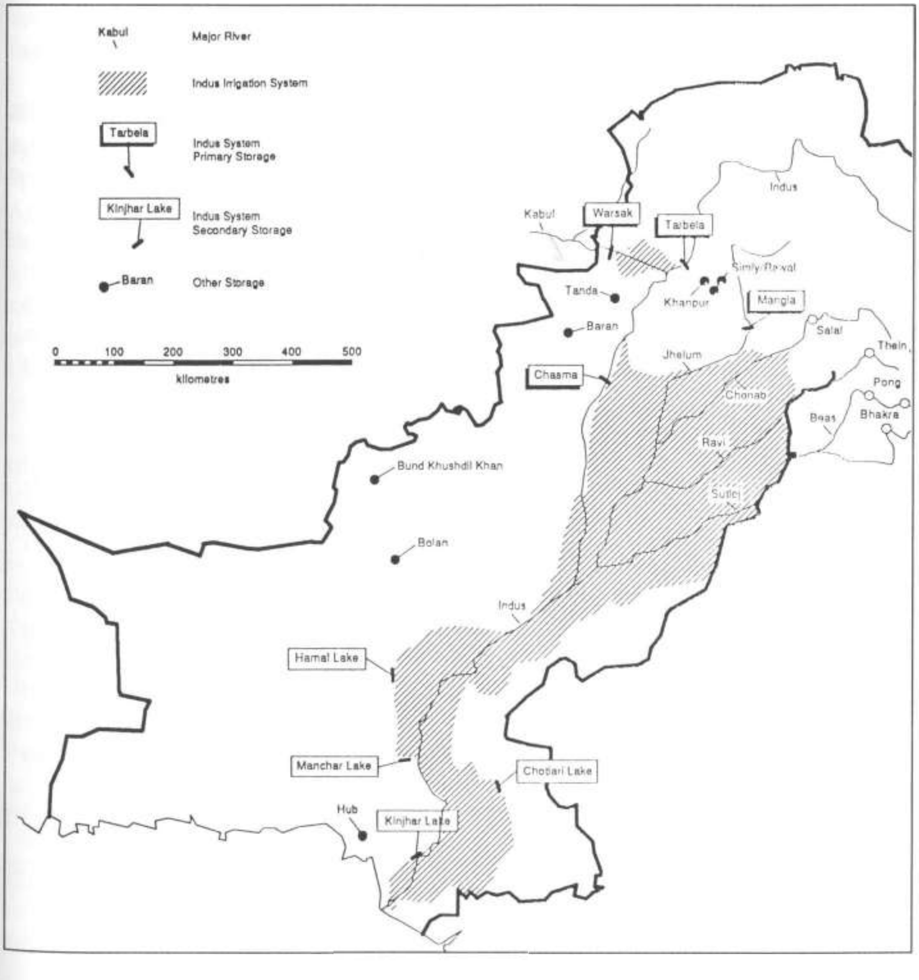


Figure 1. *Indus irrigation system and surface storage.*

Over the 11 years from 1976 to 1987, the average annual total inflow was 180 billion m³ (146 MAF) and canal withdrawals amounted to 129 billion m³, with 43 billion m³ (35 MAF) being released below the lowest barrage, Kotri, i.e about 24% of the original available flow (see Table 2). Even below Kotri the waters are used for irrigation and are subject to evaporation so that only about 25 billion m³ (20 MAF) actually reach the Indus delta. In some dry years, the discharge falls below 12.5 billion m³ (10 MAF); in these years it can be assumed that virtually no

Table 2. *Review of last 11 years of system operation (1976/1977–1986/1987).*

SOURCE	Kharif		Rabi		Annual	
	billion m³	MAF	billion m³	MAF	billion m³	MAF
A. MEAN INFLOWS						
Rim Stations						
Western Rivers	132.26	107.22	26.19	21.23	158.44	128.45
Eastern Rivers	9.25	7.50	2.39	1.94	11.64	9.44
Tributaries/Direct Inflow						
Western Rivers	6.30	5.11	3.28	2.66	9.58	7.77
Eastern Rivers	0.75	0.61	0.15	0.12	0.90	0.73
Total inflows	**148.56**	**120.44**	**32.01**	**25.95**	**180.57**	**146.39**
B. RESERVOIR OPERATION[1]						
Tarbela Reservoir						
Water stored	11.92	9.66	–	–	11.92	9.66
Late Kharif release	1.48	1.20	–	–	1.48	1.20
Rabi release	–	–	8.40	6.81	8.40	6.81
Early Kharif release	2.04	1.65	–	–	2.04	1.65
Mangla Reservoir						
Water stored	5.75	4.66	–	–	5.75	4.66
Late Kharif release	0.38	0.31	–	–	0.38	0.31
Rabi release	–	–	5.37	4.35	5.37	4.35
Early Kharif release	–	–	–	–	–	–
Chashma Reservoir						
Water stored	0.76	0.61	–	–	0.76	0.61
Late Kharif release	0.38	0.20	–	–	0.25	0.21
Rabi release	0.25	–	0.49	0.40	0.49	0.40
Early Kharif release	–	0.01	–	–	0.02	0.01
C. CANAL WITHDRAWALS						
NWFP	6.66	3.78	2.83	2.29	7.49	6.07
Punjab	41.40	33.56	24.97	20.24	66.36	53.80
Sind/Balochistan	36.13	29.29	19.08	15.47	55.21	44.76
Total Withdrawals	82.19	66.63	46.88	38.00	129.06	104.63
D. RELEASES BELOW KOTRI						
	41.00	33.24	1.96	1.59	42.96	34.83
E. SYSTEM GAINS AND LOSSES						
Losses	18.74	15.19	–	–	18.74	15.19
Gains	–	–	4.69	3.80	4.69	3.80

Source: WAPDA, 1989, Surface Water Potential - Draft, Planning Division, May 1989.

[1]Note: Volumes in reservoir operation include a small component of reregulation within a season.

freshwater reaches the sea, and even in wet years the Indus will only reach the sea for three months per year.

In March 1991, the governments of the four provinces of Pakistan came to an agreement about distribution of the waters of the Indus: the Indus Water Accord. While for the first time this recognised that flows of freshwater to the delta are important to maintain the mangrove ecosystem (a minimum of 10 MAF was agreed) it is clear that the extra water apportioned over and above the current usage will be taken from the water discharged to the delta. There is currently considerable political debate about the proposed construction of another major dam at Kalabagh. This dam is likely to reduce the discharges to the delta even further.

Effects of water diversion and irrigation on the Indus

As the irrigation system developed with the construction of thousands of kilometres of unlined water channels, a new source of groundwater recharge was introduced, and with no new outlet for it, the hydrological balance was disturbed. The result was that in many areas in the CCA the water table rose, and on reaching the surface evaporated causing deposition of the dissolved salts in the surface layers of the soil. Two major problems thus accompanied the development of the irrigation system – waterlogging and hypersalinity. The water table has risen to within 2 m of the surface over 25% of the basin, and to within 3 m of the surface in 33% of the Indus Plain. It has been estimated that 40,000 hectares of the irrigated land are lost each year due to waterlogging and salinity. Currently 5.7 million hectares of land are affected by saline groundwaters. The extent of these twin problems is shown in Figure 2.

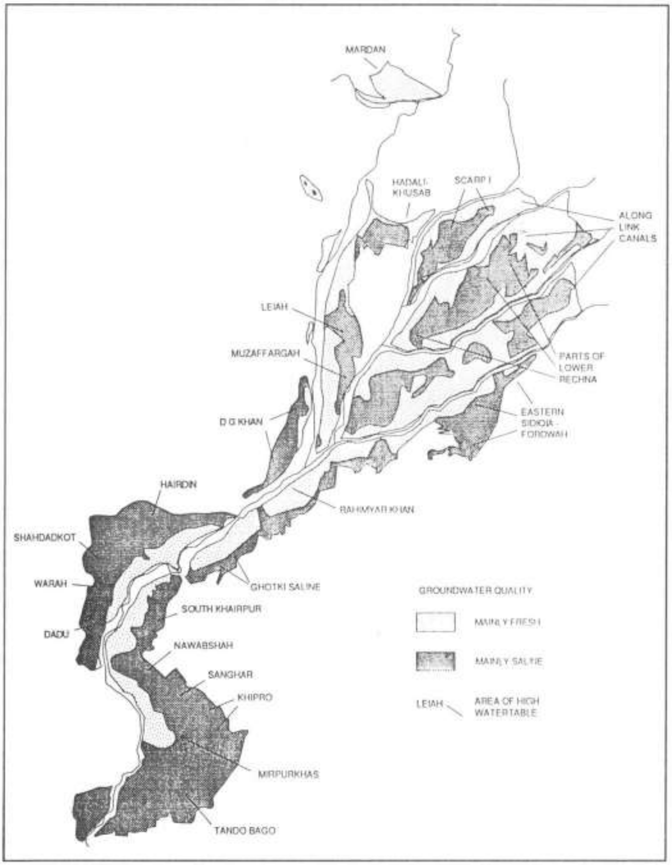


Figure 2. *Saline groundwater areas and principal areas of high watertable.*

In recent years several major schemes have been proposed to improve drainage in an attempt to reduce the waterlogging, in particular the Left and Right Bank Outfall Drains. These schemes involve pumping groundwaters into drainage canals which then discharge the saline ground waters at suitable disposal points. The Left Bank Outfall Drain will be completed within the next few years and will discharge into the Indus delta near the border between India and Pakistan. While this may begin the redress the hydrological balance and return waters less saline than sea water to the mangrove creeks, problems may arise later with the run-off of agricultural chemicals into these drains, and thence into the mangrove ecosystem.

Mangroves of the Indus delta

The Indus delta occupies a total area of 600,000 hectares which consist of:

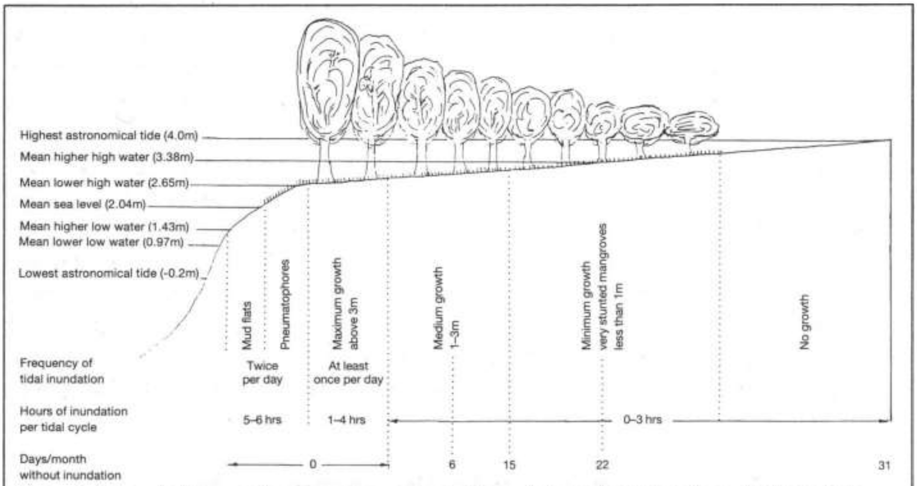
Dense mangroves	50,000 hectares	9% of total area
Normal mangroves	210,000 hectares	35%
Sparse or no mangroves	140,000 hectares	22%
Sand	40,000 hectares	7%
Water channels	160,000 hectares	27%
Total	**600,000 hectares**	

The total area covered by mangroves is about 260,000 hectares, which is significant as it is probably the largest area of arid climate mangroves in the world. (Recent satellite imagery has indicated that 1990 mangrove coverage may be reduced to 160,000 hectares, due in part to real losses and to differences in image interpretation.) The total area of delta is roughly comparable to the forested area of the Sundarbans on the other side of the Indian subcontinent.

The Indus delta mangroves are characterised by a single species, *Avicennia marina* (over 98% of the mangrove cover), although species such as *Rhizophora mucronata* used to grow there and were exploited preferentially for fuelwood. In addition some small isolated stands of *Ceriops tagal* and *Aegeciras corniculata* are still found. The growth patterns of the Indus delta mangroves show the largest trees (up to 10 m) fringing the banks of the creeks, with the size of the trees diminishing with the height of ground level and decreasing regularity of tidal inundation (see Figure 3). Generally the height of the mature *Avicennia* is 3–5 m, a degree of stunting which is caused by the high salinities in the creeks and soil pore waters. Salinities in the creeks are regularly 45 ppt and above, i.e. considerably more than sea water, and in the soils the salinity in the backwaters can reach up to 65 ppt.

The distribution of mangroves in the Indus Delta is shown in Figure 4, with the largest blocks of mangrove growing to south and north of the one remaining mouth of the Indus. The mangroves are considered as a protection forest and the largest two areas are under the control of the Sindh Forest Department. It is strange that the area surrounding the mouth of the Indus has perhaps the lowest density of

Figure 3. Schematic profile of fringing mangroves in Indus delta creeks.



Note: heights of tides are shown as above chart datum. Tidal information from Pakistan Tide Tables 1991, using December 1991 figures.

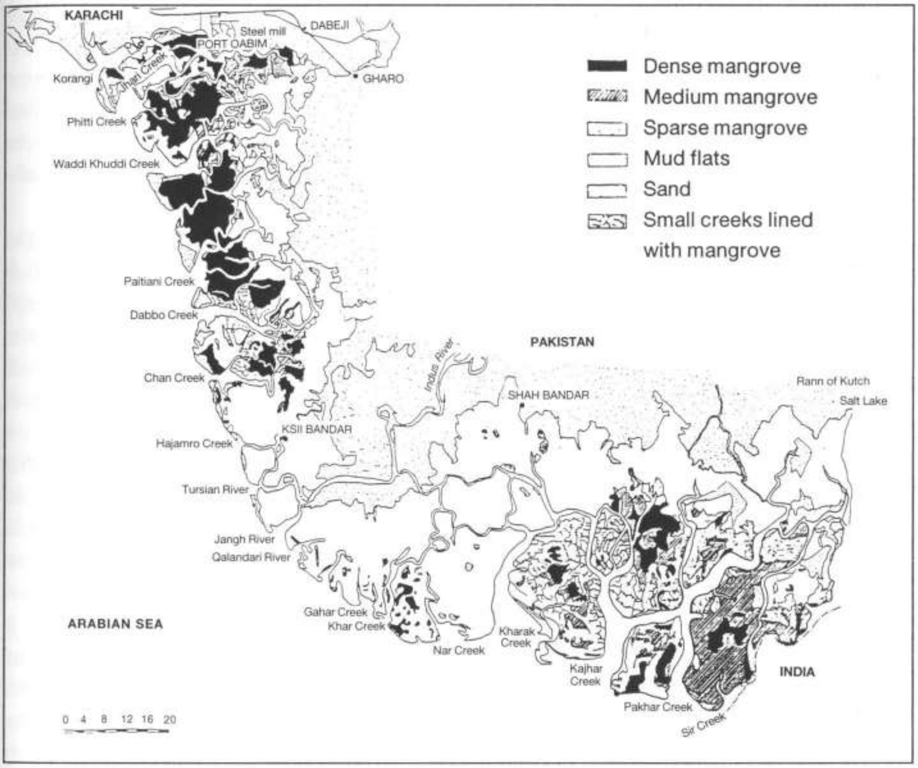


Figure 4. Mangrove cover in the Indus delta interpreted from 1990 SPOT imagery.

mangroves, since one would expect that having the greatest amount of freshwater available, the mangroves would grow most profusely. However, this area is in theory controlled by the Central Board of Revenue because of the agricultural lands which used to be cultivated there when the Indus flowed more strongly. It is suspected that a combination of no control and previous clearance for cultivation has decimated the mangrove stands in this area. Probably the most profuse stands of mangrove are growing in the creeks nearest the north coast of the delta, where they receive some freshwater and nutrients from the discharge of sewage and industrial waste waters from Karachi. This is also the area which is perhaps the most hydrologically stable as the Indus river has moved southwards over the years.

The Indus delta mangroves are important as a nursery ground for fish especially for the commercial and artisanal shrimp fishery. This is a valuable export earner for Pakistan. In addition to this the wood is used by coastal populations for fuelwood and the leaves as fodder for their animals. There are about 16,000 camels herded in the mangroves at certain times of year. The mangroves also provide coastal protection against the south-west monsoon, especially for Pakistan's second port, Port Qasim. As a significant wetland area, the creeks are an important wintering ground for waders and waterfowl migrating down the Indus Flyway No. 3. There are currently discussions on the creation of a National Park in the Indus delta or some other means of protection.

Effects of reducing flows to the Indus delta

As the flows of freshwater down the Indus have decreased over the last 50 years, so the stress upon the mangroves has increased due to several factors.

The first is the increase in salinity of the creek waters. *Avicennia* is one of the most salt-tolerant of all mangrove species and so it is not surprising that this species has become the most dominant, almost to the exclusion of all other species. However, even *Avicennia* is suffering from stunting due to high salinities and to a changing survival of seedlings. This means that not only do the trees mature at lower heights, but that there are fewer younger year-groups to replace them. Once some of the existing stands die or are cut, there would appear to be nothing to take their place.

As well as freshwater which diluted the salinity in the Indus delta, the river brought significant quantities of silt and nutrients into the mangrove ecosystem, both of which were important for its growth and survival. Before the Indus was dammed, some 400 million tonnes of silt were deposited in the Indus delta each year. The delta front used to progress out into the Arabian Sea at a rate of up to 30 m per year and soft riverine sediments used to dominate, providing the balance between deposition and erosion. With reduction of the silt load coming down the Indus to less than 100 million tonnes per year (and probably lower in the future) this balance has changed. Not only have marine sediments begun to dominate in some areas, making the substrate harder and less easy for the mangrove propagules to set, but also the fan shape of the delta is beginning to show signs of flattening as the frontal areas are eroded away. These changes are likely to be accentuated if the flows down the Indus are further reduced and sea level rises increase the dominance of marine processes.

There are also indications of change occurring in the fish populations as well as in the mangroves. While overfishing has become a significant factor affecting fish populations, due to increasing numbers of fishermen and improved fishing technologies, there is also no doubt that the reduction in the flows of freshwater down the Indus has seriously reduced the fishing potential. Between 1950 and 1990 the total fish catch increased steadily as effort increased and technology improved, but the catch per boat dramatically decreased from the start of operation of the Kotri Barrage in 1956, which caused the biggest single reduction in flows to the delta.

Reintroducing Rhizophora *into the Indus delta.* Photo: P.-J. Meynell.

What can be done to protect the Indus delta mangrove ecosystem?

From the foregoing description it can be seen that diversion of the Indus, for such a major irrigation system as Pakistan is now dependent upon, has had serious environmental consequences which were not appreciated at the time. Up until ten years ago (and even now in some quarters) any water discharged below Kotri barrage was considered as wasted. The mangroves were viewed as a wastelend which nobody could do much with. This attitude is changing, and this is perhaps the first step in protecting this unique ecosystem.

However, it is unrealistic to imagine that we can put back the clock, and revert to the flows which originally came down the Indus. This would be politically unacceptable, especially in the light of rapid population growth. We therefore have to accept that in some years the Indus delta will receive no freshwater, even though the minimum agreed outflow should be 10 MAF. Such freshwater as is released may also be discharged as a single amount over a matter of days in order to keep the channels free, rather than over several months as in the natural pre-dam system.

On the other hand the discharge of slightly saline waters from the drainage canals will provide some dilution of the very saline creek waters. It is expected that these will be discharged at additional points throughout the delta, which will serve to spread the effects somewhat. In addition increasing urban water usage and discharge will also contribute a small amount of freshwater to the northern creeks. The treatment of industrial and domestic sewage will do much to make this discharge more acceptable, although this may be at least a decade away.

So the protection of the Indus delta will depend upon management measures to limit the damage of previous freshwater abstraction and to work with the expected discharges. It must however be realised that such measures will be working with an ecosystem which is still responding to degradation which was initiated 50 years ago and may take another 50 years before the full effects are fully worked through.

The management measures include:

- Planting programmes to re-establish *Rhizophora* movement in the Indus delta using propagules taken from the Makran Coast (Balochistan), which receives no freshwater inflow. It is suspected that these strains of *Rhizophora* may be more salt tolerant than the original ones from the Indus delta.
- Protection and planting of *Avicennia* in suitable sites, especially where over-exploitation has clear-cut the site.
- Working with local coastal communities to reduce exploitation, e.g. by planting other non-mangrove fuelwood trees as alternatives, or by rotational cropping of different stands of mangroves for fuelwood and fodder. It is probable that the Indus delta mangroves would never be capable of being commercial production forests, since the environmental conditions are not sufficiently favourable.
- Increasing awareness among the decision makers of the value of the mangroves, and among the coastal communities of the threats to the ecosystem on which they depend. The prevailing attitude among the villagers is that the mangroves are God-given and will always be there, even though they are often aware of many of the signs of deterioration.
- Developing alternative sources of employment for coastal communities both within the mangrove ecosystem, such as mangrove honey production and tourism/recreation services, and outside the mangrove area to reduce pressure on fisheries etc.

These measures form a part of the sustainable management plan for the mangroves which is being developed between IUCN-Pakistan and the Sindh Forest Department for the Korangi-Phitti Creeks, the nearest part of the Indus delta to Karachi. This will serve as a model for the Indus delta as a whole in the next phase of the project.

Peter-John Meynell, Cobham Resource Consultants, 7–9 Mentone Gardens, Edinburgh, EH9 2DJ, UK.
M. Tahir Qureshi, Director, Coastal Ecosytem Programme, IUCN Pakistan, 1 Bath Island Road, Karachi 75530, Pakistan.

Protection of North Selangor Peat Swamp Forest, Malaysia

NATHER KHAN

Peat soils occupy a total area of about 809,000 ha, constituting some 6% of the total land area in Peninsular Malaysia. Originally, the entire area was probably forested; however, only 497,276 ha remained forested in 1954. Much of this peat swamp forest has been cleared for agriculture and tin-mining. In addition to this, natural forests on peat soils have been commercially exploited for timber for over 40 years. The cumulative effect of these pressures is the rapidly diminishing area of primary forest and damage to its natural resources and wetland functions, particularly hydrology and water resources.

The North Selangor Peat Swamp Forest, covering an area of 75,000 ha, is located along the eastern border of the North-west Selangor Integrated Agricultural Development Project area, one of the largest rice cultivation areas in Malaysia. The swamp forest is identified as the most important 'west coast' peat swamp in Malaysia and is of significant national and international importance. It has also been identified as one of the three priority wetlands in Peninsular Malaysia for management implementation. The swamp also plays an important role in mitigating flood waters and controlling pollution. Clearance or drainage of this peat swamp forest would, among other things, eliminate a temporary water storage function currently benefiting the irrigation network, increase flooding and sediment load, affect water quality, and accelerate saline water intrusion to upstream areas and rice-growing schemes.

THE PRINCIPAL TYPES of wetland in Malaysia are peat swamp forest, freshwater swamp forest, rivers, mangroves, lakes, marshes, *Melaleuca* swamps and constructed wetlands such as reservoirs, mining ponds and rice fields (Figure 1). The bulk of the wetlands in Malaysia are comprised of peat swamp forest. Some 2 million ha of peat swamp forest remain in Malaysia; about 75% is in Sarawak, and about 60,000 ha in Sabah. At the beginning of the present century, there were over 1.5 million ha of wetlands in Peninsular Malaysia alone. However, the 1,076,670 ha of wetlands or swamp lands still existing in 1966 were reduced to 977,004 ha in 1974 (MWWG 1988). Coulter (1957) estimated a total area of about 809,000 ha of peat soil in Peninsular Malaysia, constituting 6% of the total land area. All this peat soil occur on the flat coastal plains of the central and southern parts of Peninsular Malaysia. The peat swamps in the west coast are overlain by rich alluvium whereas on the east coast they are covered mainly by sand. Originally, forest could have covered the entire area of peat soil; however, Wyatt-Smith (1954) recorded only 497,276 ha of peat swamp forest. Much of this peat swamp forest has since been cleared for conversion to agriculture and other uses (Abdul Jalil *et al.* 1989).

Peat swamp forests are valuable for sustainable timber extraction, for water supply, for pollution control and flood mitigation. Deep peat areas are not normally suitable for agriculture. Large scale conversion of peat swamp forest to other land uses has tremendously devastating impacts on the environment which are not accounted for in the cost/benefit analyses normally prepared for such projects.

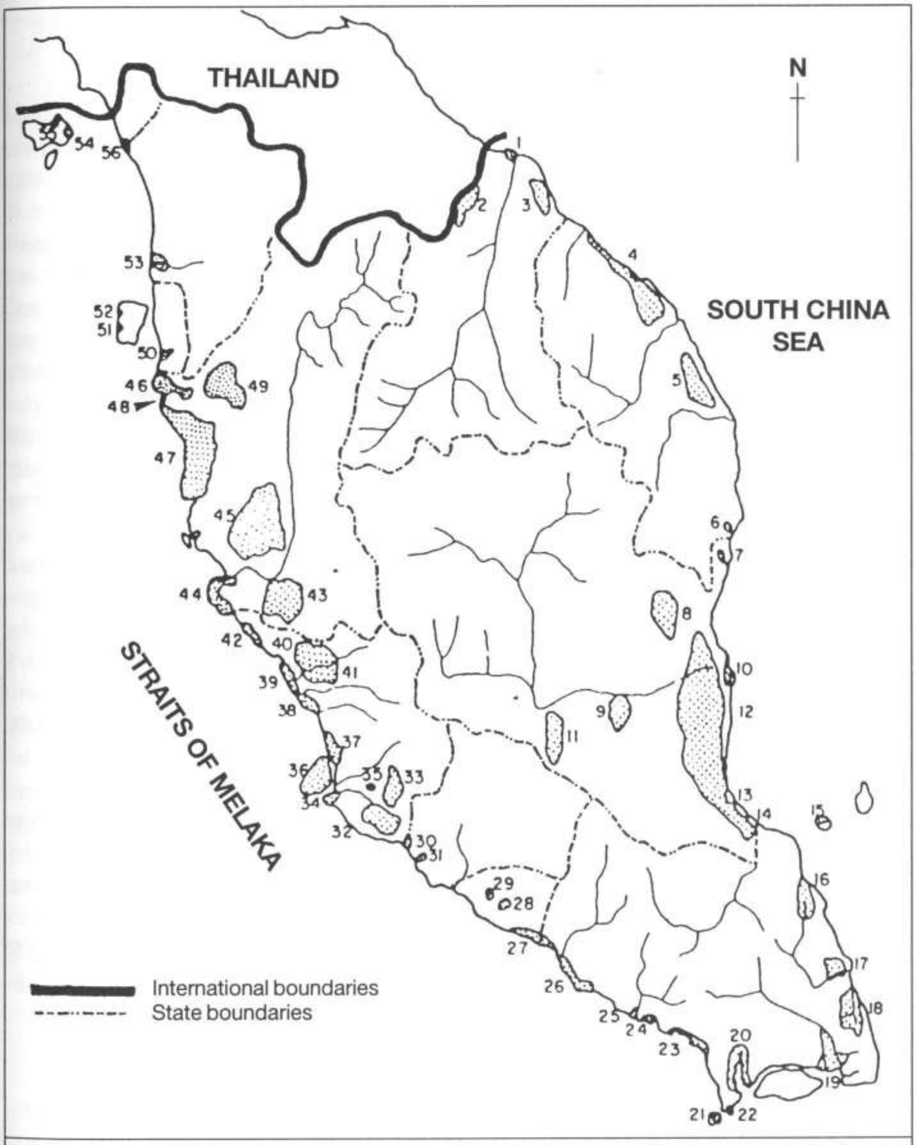


Figure 1. *Major wetland sites in Peninsular Malaysia (after Malaysian Wetland Working Group 1988).*

KELANTAN
1. Tumpat Lagoon
2. Sungai Golok *Melaleuca* Swamp

TERENGGANU
4. *Melaleuca* north of Kuala Terengganu
5. Merchang Bukit Terendak Swamp Forest
6. Kemaman Mangrove Forest Reserve

PAHANG
7. Sungai Cherating Mangrove Forest
8. Ulu Lepar Lakes
9. Tasek Cini
10. Tanjung Agas
11. Tasek Bera
12. South-east Pahang Swamp Forest
13. Kuala Rompin Mangroves
14. Kuala Endau Mangroves
15. Pulau Seri Bust

JOHOR
16. Jemaluang Swamp Forest
17. Sungai Sedili Besar
18. Sungai Sedili Kecil
    i. Kuala Sedili Kecil Mangroves
    ii. Sedili Kecil Swamp Forest
19. Sungai Johor
20. Sungai Pulai
21. Pulau Kukup
22. Parit Sekolah – Tanjung Piai
23. Benut Mangrove Forest
24. Kampung Minyak – Sungai Suloh Kecil
25. Sungai Batu Pahat Mangroves
26. Muar River – Tanjung Tohor

MELAKA
27. Sungai Muar – Jerimbun Mangroves and Foreshore
28. Sungai Gapam/Ayer Panas *Melaleuca* Swamp
29. Batu Berendam *Melaleuca* Swamp

NEGERI SEMBILAN
30. Sepang Mangrove Reserve
31. Lukut Mangrove Reserve

SELANGOR
32. Kuala Langat South Forest Reserve
33. Kuala Langat North Forest Reserve
34. Jugra Forest Reserve
35. Telok Forest Reserve
36. Klang Islands
    i. Pulau Ketam
    ii. Pulau Tengah
    iii. Pulau Lumut
    iv. Pulau Kelang
    v. Pulau Selat Kering
    vi. Pulau Pintu Gedong
    vii. Pulau Che Mat Zin
37. Kapar Forest Reserve
38. Kuala Selangor Mangrove Forest
    i. Banjar North Forest Reserve
    ii. Banjar South Forest Reserve
39. Sekinchan Mangroves
40. Sekinchan – Tanjung Karang Ricefields
41. North Selangor Swamp Forest
42. Tanjung Burung

PERAK
43. Melintang Swamp Forest
44. Rungkup Peninsula
45. Telok Intan Swamp Forest
46. Krian Ricefields
47. Matang Forest Reserve
48. Sungai Burong, Kuala Kurau
49. Beriah Swamp Forest
    i. Lembah Beriah
    ii. Bukit Merah Reservoir

PULAU PINANG
50. Byram Mangroves
51. Balik Pulau Mangrove
52. Pantai Acheh

KEDAH
53. Merbok Forest Reserve
54. Kissap Forest Reserve
55. Ayer Hangat Forest Reserve

PERLIS
56. Kuala Sanglang

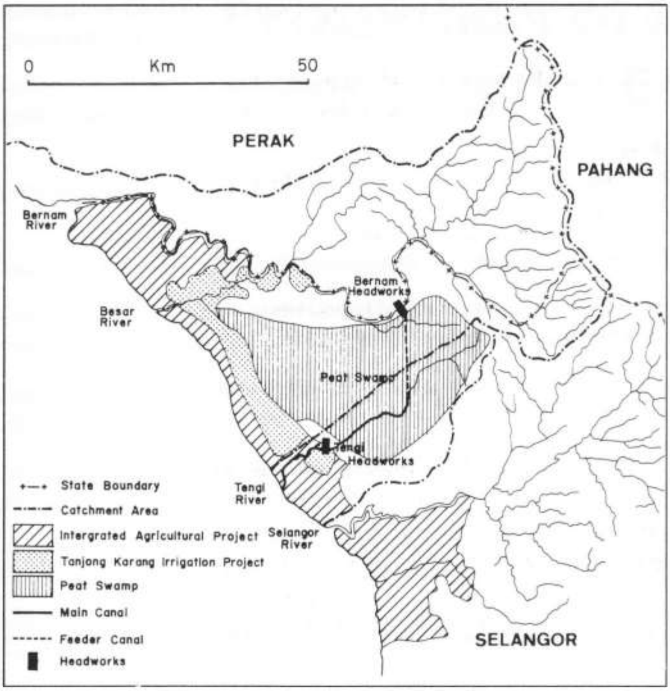


Figure 2. Location of the North Selangor Peat Swamp.

North Selangor Peat Swamp Forest and agriculture

In Peninsular Malaysia, the largest tract (over 300,000 ha) of peat swamp forest is presently found in South-east Pahang, of which approximately 80,000 ha is classified as forest reserves. The North Selangor Peat Swamp forest is the second largest, comprising about 75,000 ha, and is considered as a mixed peat swamp forest (Wyatt-Smith 1959, Anderson 1961, Whitmore 1984). This forest also includes two forest reserves, namely the Sungai Karang Forest Reserve (36,655 ha), and the Raja Musa Forest Reserve (36,161 ha).

The North Selangor Peat Swamp Forest is located between Sungai Selangor in the south and Sungai Bernam in the north. It is bounded to the west by a major irrigation canal supplying the North West Selangor Integrated Agricultural Development Project or Tanjung Karang Rice Scheme, one of the largest rice cultivation areas in the country. In the east, the swamp reaches its natural margin at the foot of low rolling hills or terminates where land has been cleared for agricultural purposes. Sungai Tengi runs through the peat swamp, being canalised along most of its course and linked to Sungai Bernam by a feeder canal in the north-eastern corner of the peat swamp. More than 60% of the swamp area receives rainfall over 2,000 mm per annum, while at least 25% receives 2,500 mm or more. Maximum monthly rainfall occurs mainly in November, ranging from 185–413 mm. The driest month is in June with monthly rainfall ranging from 76–191 mm.

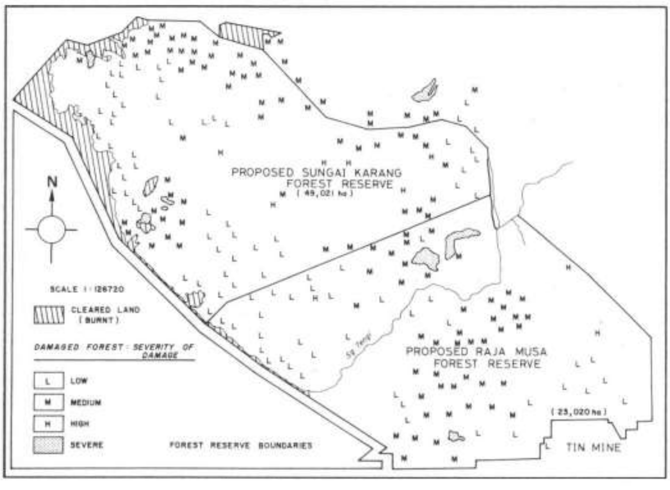


Figure 3. Two forest reserves and scale of forest damage due to logging (Chan 1989).

Forestry and logging

Most of the North Selangor Peat Swamp Forest has been logged over many years and limited relogging is currently in progress (Chan 1989). It is most unlikely that there remains any virgin forest in the swamp. The damage to the forest from pre-1983 logging was classified and mapped. The damage after the 1983 logging could not be assessed due to lack of aerial photos, but it is known to be extensive (Figure 3). Part of the peat swamp has been drained and cleared in the south-eastern corner to make way for tin-mining and the north-western portion of Sungai Karang Forest Reserve has been partially cleared for agriculture.

The current system of logging using tracked machinery and canal extraction is severely damaging to the forest, particularly along extraction tracks which lead to the extraction canals. The logging companies dig several extraction canals of various sizes and lengths to facilitate the transportation of logs to the river and swamp edge. Based on information provided by loggers, the length of some of the canals was estimated to be about 5 km. They then establish extraction tracks from the extraction canals to the sites of the commercial trees by bulldozing down all the trees along the way. It is very common to find an intricate network of these tracks, completely devoid of vegetation or densely colonised by a few non-commercial species if they are old tracks.

Wetland values

The North Selangor Peat Swamp Forest is a valuable wetland of national importance. It contributes an assortment of benefits including water supply, ground water recharge, flood control, sediment and nutrient retention, prevention of saline water intrusion, toxicant removal, and protection against natural forces such as strong winds. It is a storehouse for natural forest resources and is a habitat that supports a vast diversity of flora and fauna. Some of the notable means of exploitation of the Peat Swamp Forest's resources are given below.

Timber and forest products

It is the largest tract of lowland forest in the State, containing important timber species and is an important source of forestry resources. In terms of timber production, the Sungai Karang Forest Reserve is one of the most productive in the country (Chan 1989). However, certain logging methods and uncoordinated logging activities appear to have a major negative impact.

Tin-mining

An area of approximately 10,000 ha in the south-eastern corner of the forest has been designated for tin-mining, most of which has already been exploited a few times. Certain areas allocated for tin-mining are still under forest cover but this is now being logged.

Peat-mining

A small joint Malaysian-Finnish venture has recently set up a peat-mining operation on the land controlled by tin-mining companies. The peat is milled and bagged-up for horticultural use.

Agriculture

Currently, agriculture in the North Selangor Peat Swamp Forest is limited to cultivation of vegetables and fruit trees on the muck soils, and oil palm plantation on the shallower peat soil. However, agriculture is not compatible with sustainable utilisation of forestry and should not be permitted to take place inside the forest reserve.

Recreation

Recreational use of the North Selangor Peat Swamp is generally limited to fishing, with some hunting and bird-watching. However, extensive logging stops it from

A pair of Brahminy kites, Haliastur indus, *one of 173 bird species recorded at the North Selangor Peat Swamp Forest.* Photo: P.-J. Meynell.

being a major destination for bird-watchers, although it has the potential to be developed into a great recreation and tourism centre.

Biological diversity

No extensive floral and faunal studies have been conducted at the North Selangor Peat Swamp Forest except for a few recent preliminary surveys (Prentice and Aikanathan 1989, Davies and Abdullah 1989). A diverse tree flora was recorded in the natural and logged-over forest and all the tree species that were identified in the forestry plots are listed in Chan (1989). A total of 28 mammalian species have been recorded so far in this swamp forest (this includes four species of primates, Sumatran rhinoceros, Asian elephant, black panther, Malayan sun bear and Malayan giant fruit bat; Marsh 1980, Ratnam 1982, Mohd. Khan 1985, Prentice and Aikanathan 1989). A total of 173 species of birds have been recorded, of which 145 are breeding residents, 21 are non-breeding migrants and a few are threatened species. A number of reptiles and other fauna were also recorded. Among 100 fish species belonging to 11 families recorded in a preliminary survey, at least 11 are considered endangered, five are considered rare and four endemic (Davies and Abdullah 1989, Tay *et al.* 1992). A more extensive survey of this swamp forest would reveal further rare and endemic species, as well as species with potential for commercial use.

Hydrological functions

The North Selangor Peat Swamp lies within the Kuala Selangor Hydrological Region. The area is defined in general terms as having loose clayey and sandy deposits with the lowest category of potential water run-off (Goh 1974). The water balance of the swamp was studied by examining the relative inflow and outflow of the water.

Water inflow

The swamp derives most of its water from rainfall, having an annual rainfall of about 2,300 mm. With a known slope of 1:2,000 towards the Sungai Bernam Headworks (JICA 1987) and a higher rainfall in the north-eastern part of the swamp, a general flow towards the Sungai Tengi Headworks (south-westward) could be expected. However, in the north-west, flow is probably mostly westward towards the main canal because of the prevailing hydraulic gradient. Drainage towards the other swamp margins has been observed in extraction canals and ditches. During high flow periods or when large amounts of water are released at Sungai Bernam Headworks, the feeder canals and Sungai Tengi overflow into the swamp.

Water outflow

A large proportion of the outflow occurs through evaporation and transpiration. The main annual evapotranspiration of the swamp forest was estimated to be 1,630 mm or 135 mm per month. Five rainfall stations near the rice scheme receive less rainfall than the evapotranspiration for at least half the year. Therefore, water shortages during dry periods are expected and supplementary irrigation water is obtained from Sungai Bernam. Another major means of water flow from the swamp is through the numerous log extraction canals and drainage ditches, some of which flow into the main canal and Sungai Tengi. A 5 km drain of 2 metres width and 1 metre depth was estimated to be draining about 50–60 l s^{-1} during the dry season. This gives a drainage rate of 10–12 l $s^{-1}km^{-1}$, which is much higher than the values of 3.56 l $s^{-1}km^{-1}$ reported by JICA (1987). The network of drainage ditches and extraction canals is resulting in extensive drainage of the surface of the swamp, particularly where canals penetrate domed sections of the swamp.

Water storage function

Approximately 480,000 ha of the swamp contribute water to the irrigation network. Given annual rainfall and evapotranspiration levels of 2,305 mm and 1,630 mm respectively, there is an excess of 675 mm of water annually. This is equivalent to 324 million cubic meters of water per year.

Part of this water is stored temporarily within the swamp, while the rest leaves the swamp immediately as surface or sub-surface runoff. The temporary storage function of the swamp is one of its most important hydrological attributes. This function is enhanced by the fact that the peat is underlain by relatively impermeable clay, reducing losses to groundwater. Thus, ground water recharged from the swamp will be less than from surrounding areas and this enables water to be stored within the peat layers for a longer period. Soil moisture depletion was found to be a slow process, indicating the value of the swamp as a source of irrigation water during dry periods.

Flood mitigation

The peat swamp is already effectively being used for flood control by the Drainage and Irrigation Department. Every year, usually in November, flood waters are diverted from Sungai Bernam into the feeder canal in order to reduce flood peaks in the river, thus protecting the downstream agricultural land, oil palm plantations and the town of Sabak Bernam from flood damage. The diverted water overflows into the large area of peat swamp land for temporary retention and further excess can be tapped off at the Sungai Tengi Headworks if necessary. The buffering effect of the peat swamp is apparent from the change in water level fluctuation between the feeder canal and Sungai Tengi Headworks. Water level in the feeder canal is more variable than at Sungai Tengi Headworks during the flood peak.

Protection and management

It is clear that North Selangor Peat Swamp Forest contributes a significant amount of water into the rice scheme irrigation network, especially during the early part of the dry periods. It retains water during wet periods and releases water slowly during drier periods. Clearance or drainage of the peat swamp forest may eliminate the temporary storage function currently benefiting the irrigation network. In addition, reduced flow in the Sungai Bernam due to increased intake for agriculture would affect water users downstream. It would also result in saline intrusion upstream in Sungai Bernam. Drainage ultimately destroys the 'sponge effect' of the peat swamp due to irreversible drying of the soil, and its reservoir function is lost (Andriesse

1988). Diverting flood waters from Sungai Bernam would not be feasible if the swamp is converted to other land uses. The numerous log extraction canals and ditches increase extensive drainage of the swamp's surface water. This will increase further with the continuation of logging activities and the rise in the number of drains and canals. Sediment and nutrient control functions will also be lost. In order to maintain the swamp's natural but valuable hydrological functions, the peat swamp should be allowed to return to its natural hydrological condition. The most important step to achieve this is to minimise surface drainage from the swamp by blocking or filling in the numerous existing drainage ditches and log extraction canals. In future, logging methods that involve hydrological interference, such as drainage, extraction canals and surface compaction from heavy machinery, should be replaced by less damaging methods. The water table inside the peat swamp should be maintained at a high level in order to maintain its natural hydrological regime.

To protect the market and non-market values of the peat swamp forest, there should be a thorough environmentally-sound management plan. The Asian Wetland Bureau has produced an Environmental Action Plan for the North Selangor Peat Swamp Forest (Prentice 1990) intended to provide a basis for such management plants, for the use of concerned government and non-government agencies. There should be an integrated resource management approach in the area. Currently, responsibility for water supply to the rice scheme and flood control is under the control of the Drainage Irrigation Department (JPS). The supply of drinking water extracted from Sungai Bernam and the main canal is the responsibility of the Water Supply Department (JBA). The Department of Agriculture administers the rice scheme, while oil palm estates around the swamp are either under private or FELDA (Federal Land Development Authority) land. Sungai Dusun Game Reserve is managed by the Department of Wildlife and National Parks (PERHILITAN).

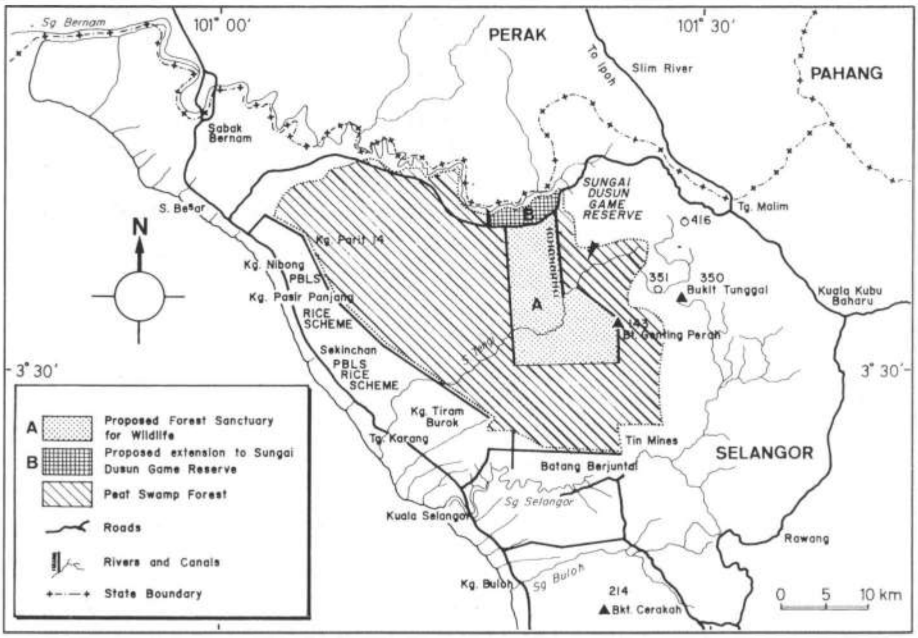


Figure 4. *Swamp forest and proposed sanctuary.*

The two forest reserves within the swamp had been under gazettement process since 1982 and were formally gazetted in January 1990. Now, the Forest Department of the State of Selangor has control over most of the peat swamp, except the tin-mining lands (Figure 4). However, additional measures and further actions are needed to protect the swamp for sustainable utilisation of its resources, particularly the hydrological function which is considered important for the survival of the rice scheme. The North Selangor Peat Swamp Forest has been identified as being one of the three priority wetlands in Peninsular Malaysia for permanent protection and management implementation.

Acknowledgements

Most of the information compiled in this paper is extracted from various AWB publications prepared by a team of experts, including Crawford Prentice, Dr Chan Hung Tuck, Dr Low Kwai Sim, Mr Balamurugan, Dr Jonathan Davies, Mr Abdullah Abdul Rahim and Ms Sarala Aikanathan. A number of government and non-government agencies have supported this study, including Selangor State Economic Planning Unit (UPPN), Selangor State Forestry Department (JPNS), Selangor State Drainage and Irrigation Department (JPT), the Department of Wildlife and National Parks (PERHILITAN), World Wide Fund For Nature (WWF) Malaysia, and the Asian Wetland Bureau.

References

Abdul Jalil, M.A., Chow, W.T., Chan, Y.K., and Siew, K.Y. 1989. Land use of peat in Peninsular Malaysia. Paper presented at *National Workshop on Peat Research and Development,* 21–22 February 1989, MARDI, Serdang, Malaysia.

Anderson, J.A.R. 1961. The ecology and forest types of the past swamp forests of Sarawak and Brunei in relation to their silviculture. Ph.D. thesis, Edinburgh University.

Andriesse, J.P. 1988. Nature and management of tropical peat soils. *Food and Agriculture Organisation Soils Bulletin* 59, FAO, Rome.

Chan, H.T. 1989. A Forestry Action Plan for the North Selangor Peat Swamp Forest. IPT Asian Wetland Bureau/WWF-Malaysia, Kuala Lumpur.

Coulter, J.K. 1957. Development of the peat soils of Malaya. *Malaya Agric, J.* 60: 188–199.

Davies, J., and Abdullah, A.R. 1989. *Freshwater fish survey off the North Selangor Peat Swamp Forest.* Asian Wetland Bureau Publ. No. 46, Kuala Lumpur.

Goh, K.S. 1974. *Hydrological Regions of Peninsular Malaysia.* Drainage and Irrigation Division, Ministry of Agriculture and Rural Development, Kuala Lumpur, Malaysia.

JICA. 1987. *Feasibility Study on the Tanjung Karang Irrigation Development and Management Project.* Japan International Cooperation Agency – Government of Malaysia, Kuala Lumpur.

Marsh, C.W. 1980. *A proposal for the conservation of swamp forest in North Selangor.* Unpubl. report, Universiti Kebangsaan Malaysia, Serdang.

Mohd. Khan bin Momin Khan. 1985. Population and distribution of the Malayan elephant *Elephas maximus* in Peninsular Malaysia. *J. Wildlife and Parks* 4: 1–16.

MWWG. 1988. *The Malaysian Wetland Directory.* Malaysian Wetland Working Group (MWWG), Department of Wildlife and National Parks, Malaysia.

Prentice, C. 1990. *Environmental Action Plan for the North Selangor Peat Swamp Forest.* AWB/WWFM, Kuala Lumpur, Malaysia.

Prentice, C., and Aikanathan, S. 1989. *A preliminary faunal survey of the North Selangor Peat Swamp Forest.* Asian Wetland Bureau Publ. No. 30, Kuala Lumpur.

Ratnam, L.C. 1982. *The Irrawaddy Dolphin of Asian Wetlands.* IUCN, Gland, Switzerland, and Cambridge, UK.

Tay, J.B., Peter, K.L., Kelvin, N.G., and Lim, K.P. 1992. *The Conservation of the Ichthyofuana of the North Selangor Peat Swamp Forest and Adjacent Areas.* Asian Wetland Bureau and National University of Singapore, Kuala Lumpur.

Whitmore, T.C. 1984. *Tropical Rain Forest of the Far East.* 2nd ed. Oxford Science Publication, Oxford.

Wyatt-Smith, J. 1954. Forest types in the Federation of Malaya. *Malay Forester* 17:83–84.

Wyatt-Smith, J. 1959. Peat swamp forest in Malaya. *Malay, Forester* 22: 5–32.

Nather Khan, 16, Jalan SS5D/11B, Kelana Jaya, 47301 Petaling, Jaya, Selangor, Malaysia.

Protected areas and dams: the case of the Senegal River delta

PIERRE POL VINCKE AND IBRAHIM THIAW

The Senegal River has been subjected to significant water-resource development projects. Two dams have been constructed on the river: one at Diama, near to the mouth of the river, is designed to exclude saline water, while the other, situated at Manantali in Mali, is a hydroelectric dam.

The development of the sub-region will depend on how these works are managed. Studies carried out as part of this important development scheme have once again raised the problem of protected areas and their integration in development schemes. The studies have shown that their future will primarily depend on governments' ability to integrate them in their planning, on the way in which they will define development policies based on an optimal management of natural resources for their national territories (which also exist outside these zones), on their ability to maintain a fruitful atmosphere of regional cooperation and on the way in which international partners react in the light of these prospects.

Examples are taken from the right bank (Mauritania) and the left bank (Senegal) of the delta of the Senegal River, to illustrate both the overall situation of the valley's natural environment and the environmental policies practised - or neglected - by the governments concerned.

THE SENEGAL VALLEY is the site of significant development. In the wake of the droughts of the 1970s and 1980s and in the light of the presumed outlook for rainfall, a regional water management programme was set up.

In 1972, a regional association, the Organisation pour la Mise en Valeur du Fleuve Sénégal (Organisation for the Development of the Senegal River, or OMVS), was set up. Two dams (see Figure 1) have been constructed – to exclude saline water at Diama, near the mouth of the river, in 1985, and for hydroelectricity at Manantali, Mali, in 1987.

National planning bodies have been created with the task of working out post-dam guidelines. In Senegal, this is the Comité National de Planification, de Coordination et de Suivi du Développement de la Vallée du Fleuve Sénégal (National Planning, Coordinating and Development-Promoting Committee for the Senegal River Valley, or CNPCS) and its executive department, the post-dam group. In Mauritania, it is the Ministry of Hydraulics and Energy which is in charge of the Supporting Technology Office, which itself plays a consultant role on the interministerial post-dam committee.

The overriding objectives of the post-dam project are the struggle against desertification, the supply of drinking water, covering national food needs, the reduction of energy dependence, the generation of earnings with which to repay debts, navigability of the river, and the restoration of regional and national balance.

Protected areas in the Senegal River delta

On the left bank (see Figure 2), there are protected areas in the rural district of Ross Bethio. These are the Djoudj bird reserve, the Ndiaël and Trois Marigots special reserves, and the listed forests of Tilène, Ndiaye, Massara Foulane and Maka Diama.

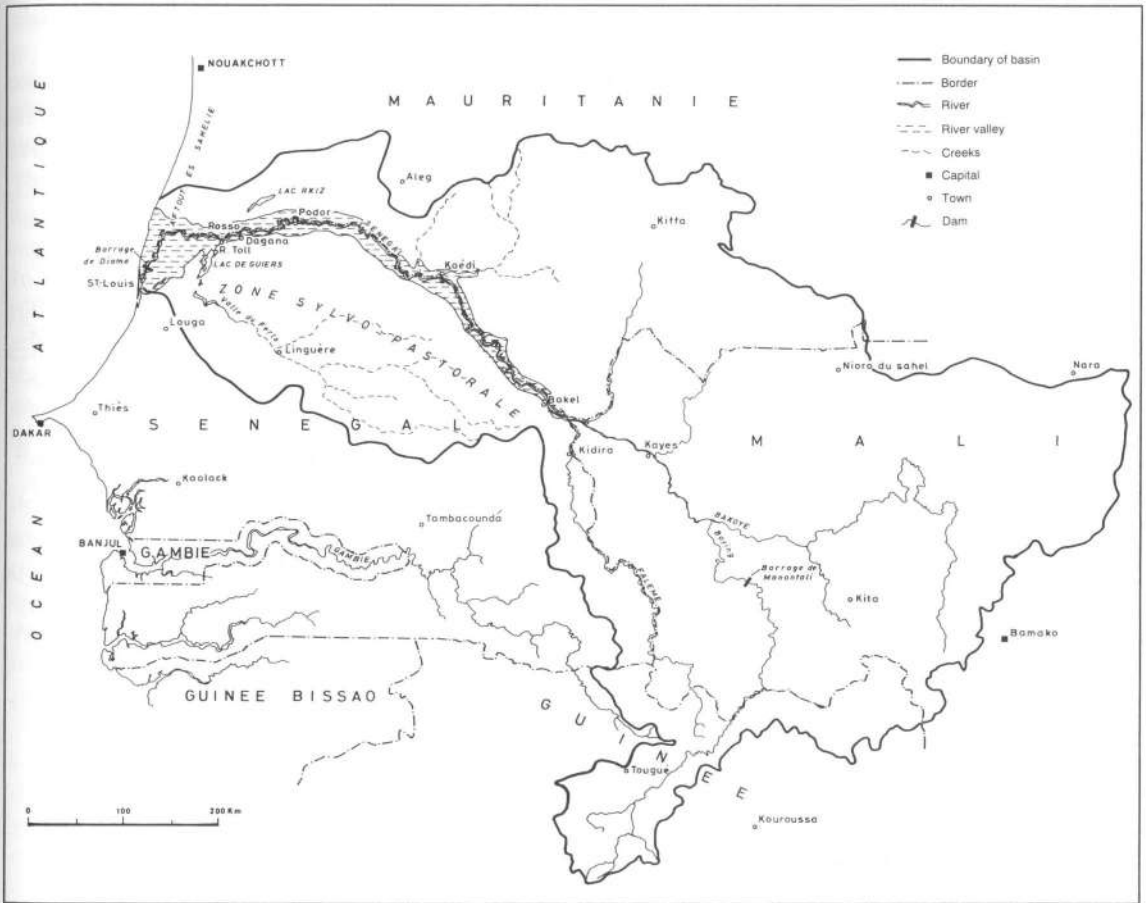


Figure 1. Senegal River basin, showing location of the Diama and Manantali dams.

The Senegalese delta is a wetland of international importance (International Waterfowl and Wetlands Research Bureau). The Djoudj park and the Ndiaël reserve are protected under the Ramsar Convention.

On the right bank is the Diawling national park, created in 1991 in the Keur Macène département. The preservation of these protected areas will take on concrete form through competition with zones of agricultural production. The search for a common denominator between the imperatives of production and the need to conserve natural resources is one of the environmental concerns at stake in the guidelines.

Guidelines for the integrated development of the left bank of the Senegal river valley (PDRG)

The PDRG is a scheme for integrated development in which the management of river water, the protection and management of natural resources, the best possible use of traditional systems of production, the modernisation of operations and the empowerment of local people will be the guarantees of the sustainable development that is planned for the next 25 years. The PDRG's accompanying measures will be supported by structural developments: the local management of land, the integration of farming, forestry and grazing activities and fishing, the privatisation and intensification of agriculture, the promotion of the PME, health, and education.

Guidelines for the integrated development of the right bank of the Senegal river valley (PDRD)

The major pillars of these guidelines are the reduction of food dependence (price incentive policy, protection of national production), government withdrawal and a redefinition of its services, and increased efficiency of public intervention. There are

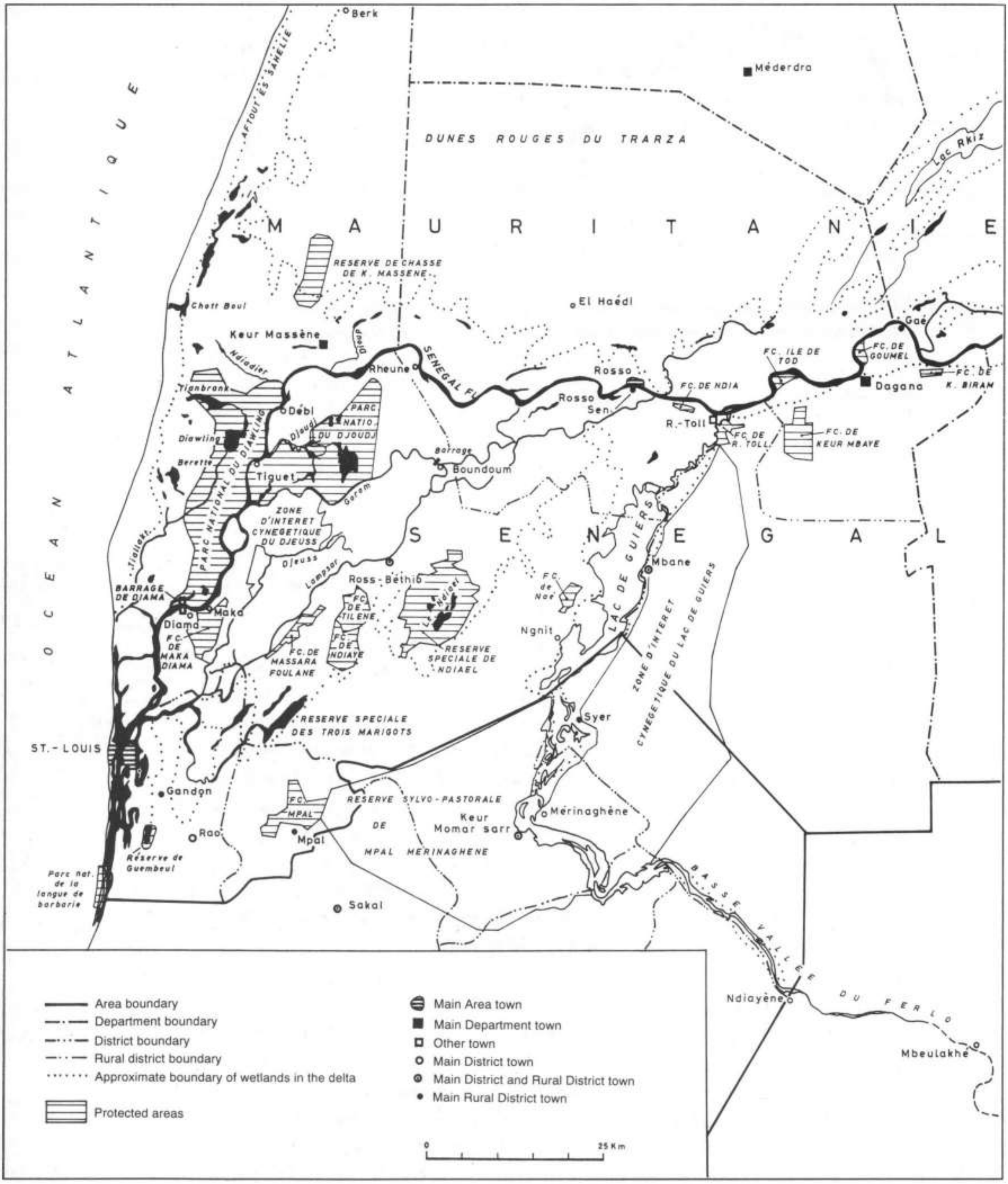


Figure 2. *Senegal River delta, showing location of protected areas.*

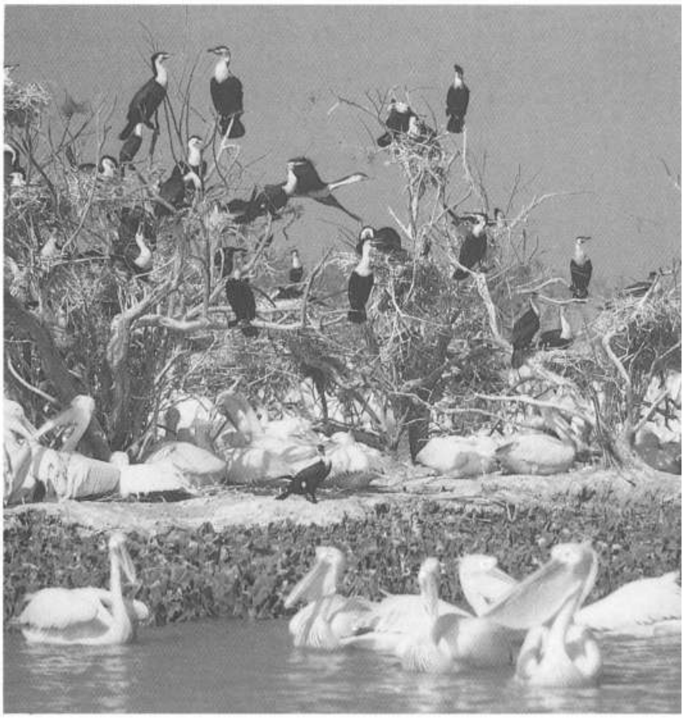
plans for a preliminary cadastral survey, a development plan for rural areas and a regional commission to look into the management of land ownership.

The importance of empowering local people to manage the land

The future of the protected areas depends on the definition and the application of agricultural policies that are based on giving local people responsibility for the management of natural land resources as a way of securing sustainable development. In spite of similar objectives on either side of the river, there are some subtle differences between the socio-economic approaches to development of the PDRG and the PDRD. In the PDRD, government withdrawal aims more at rapid liberalisation than at giving responsibility to grass-roots organisations, management of the land seems more managerial there, and there is only reduced room for the management of natural resources and for traditional activities.

Because of these discrepancies, the post-dam scheme raises the problem of the decentralisation of certain state powers and of giving responsibility to grass-roots groups. These are options which will be realised by the reinforcement or the creation of local land management institutions as indispensable mediatory institutions between users and the government. The increasing degradation of natural resources as a result of agricultural 'mining' show that the right of use must involve a duty to manage, for these resources have a price which must be taken into account when preparing agricultural policy.

From this point of view, the management of the soil becomes part of land resource management in its widest sense; resources, types of operations, rights and duties depending on specific locations, and users: socio-professional, ethnic, gender, age groups. This land management will be carried out by drawing up local development plans (land registers, cadastral survey and a plan of land allocation and occupation), which will be the mediatory institutions between the management of land resources and regional and national plans. It will result in a decentralisation of the state and a redefinition of its role. Only political willingness that is unequivocally applied can lead to this grass roots empowerment, which can only express itself democratically.



Breeding great white pelicans Pelecanus onocrotalus *and long-tailed cormorants* Phalocrocorax africanus *in the Djoudj bird reserve.* Photo: B. Tréca.

The future of the protected areas in the Senegal River delta

It is stating the obvious to say that the post-dam situation has an influence on the function of the delta, both as a result of the upstream embankments (which allow the Diama reservoir to be filled better) and of the the Diama dam (which acts as a sluice to exclude salt water, prevent saline intrusion during low-water periods and allow floodwaters to be discharged, while taking advantage of flooding to supply floodplain depressions – see below). Measures have been, or will be, taken by the governments to minimise the negative effects of these influences.

The left bank

Reassured by guarantees of sufficient water supplies, the PDRG takes the needs of environmental protection and of enhancing traditional activities into account to propose the management of a 'peri-irrigated' belt of floodplain depressions for these uses. This belt comprises the Djoudj park, the Djeuss reserve, the Trois Marigots reserve, the Ndiaël reserve, the banks of Lake Guiers and the Ferlo valley (see Figure 2).

In order to enhance traditional systems of production (crops, grazing and fishing), to rehabilitate certain flooded forests and recession-based grazing zones and to replenish groundwater, the principle of artificial flooding has been kept (generated by the Manantali dam and compatible with power generation) as a complement to natural flooding (provided by two other tributaries to the river that are not affected by this dam).

The right bank

The Mauritanian delta is made up of a network of bays, fluvial-deltaic arms and dune complexes. Although badly degraded by the droughts and the reduction in natural flooding, it can be rehabilitated. The aim of the Diawling park is the conservation of a part of the delta as a control environment and as an example of the development of natural resources.

If it were put into practice, the development of the Mauritanian delta around this park would allow a recreation of estuarine conditions. It would dampen the impact of the Diama dam on certain fish and crustaceans, whose reproduction depends on variations in salinity and the availability of spawning grounds. It would also compensate for the reduction in natural flooding and would enhance permanent or semi-permanent traditional methods of fishing, grazing or market gardening. Implementing a development of this kind will be the result not only of national political willingness, but also of regional and international cooperation.

Transplanting sugar cane, Richard-Toll plantation, Senegal River delta. Photo: X. Cogels.

The importance of cooperation

National cooperation

National cooperation is understood as national political willingness unequivocally translated into institutional measures aimed at breathing life into propositions for integrated development and nature conservation.

The post-dam plan underlines the priority of institutional measures and actions allowing local land-management potential to be developed. This step is important because, from the point of view of the valley's development, the differences of opinion between users, among them those responsible for the protected areas, will continue to be a subject of potential conflict.

The future of the protected areas will depend on the governments' ability to draw up national integrated rural development policies in which local institutions, backed up by technical services and supervisory agencies, will be responsible for the good management of the natural heritage entrusted to the users.

Regional cooperation

The post-dam plan creates a link between the imperatives of agricultural production, nature conservation and human development. However, its intentions will remain unfulfilled unless regional cooperation puts some effort not solely into water management, power transmission, and the rules of river navigation, but also, and above all, into harmonising development strategies. Agricultural policies will be the first concern, as regards nature conservation and, in particular, the management of rural areas.

International cooperation

International cooperation will be understood as the commitment of the governments' partners to translate into concrete action their declarations relating to an integrated development based on respect for man and his environment.

International cooperation plays a strategic role in the establishment of development policies. However, it must distance itself from macro-economic options of strict profitability, because human development in nature does not ensue from mere monetary earnings, but rather from a balance between economic, social and environmental profitability. International cooperation must therefore actively participate in implementing – via structural adjustment policies and bilateral and multilateral cooperation agreements – the environmental declarations of intent made at international conferences.

Conclusion – nature conservation beyond protected areas

It is becoming increasingly urgent that we make clear the important role that protected areas (and the conservation strategies that they have given rise to) ought to play in rural development and in the definition of agricultural policies that are based on a more sensible management of natural resources.

International cooperation will encourage regional cooperation and will support the definition of national rural development policies based on local empowerment in the management of land.

In this way, the future of the protected areas is also the future of man. The knowledge gained from protected areas must be taken advantage of, not solely for the survival of these zones, but above all in order to define a concept of rural development that should be promoted in systems of production in Sahelian Africa at least. There is a great risk here of seeing prospects of development jeopardised by the inability to manage the complex and fragile balance between natural resources and man.

Acknowledgements

The present article draws on work by Vincke (1987, 1990a, b), Vincke *et al.* (1987) and van Lavieren and van Wetten (1990).

References

Anonymous. 1991. *Plan Directeur de développement intégré pour la rive gauche de la vallée du fleuve Sénégal et ses quatre Schémas Départementaux (Dagana, Podor, Matam et Bakel).* Gersar, A. Gibb, Euroconsult, SONED-Afrique, Ministère de l'Economie, des Finances et du Plan, avril 1991.

Van Lavieren, B., and van Wetten, J. 1990. *Profil environmental de la vallée du fleuve Sénégal.* Euroconsult/RIN, 68pp.

Vincke, P.P. 1987. *Le Bas-Ferio. 1. Compilation des travaux et études existantes sur la basse vallée du Ferlo. II. Annexe bilbiographique.* Cellule Après-Barrages, Ministère du Plan et de la Coopération. Juillet 1987, 34 + 40 pp.

Vincke, P.P. 1990a. *L'aménagement des zones protégées, une nécessité pour le maintien de la diversité du vivant, une référence pour les générations à venir, une priorité pour une gestion plus écologique des ressources naturelles: réflexions induites à partir de l'Après-Barrages. Atelier régional de formation sur la gestion et l'aménagement des aires protégées en Afrique, Dakar et St. Louis, 10 février au 4 mars 1990.* Unesco, 13pp.

Vincke, P.P. 1990b. *L'intégration agro-sylvo-pastorale et pêche, une stratégie visant la responsabilisation des populations rurales à la gestion des ressources naturelles de leur terroir: le cas de l'Après-Barrages. Atelier régional de formation sur la gestion et l'aménagement des aires protégées en Afrique, Dakar et St. Louis, 10 février au 4 mars, 1990.* Unesco, 6pp.

Vincke, P.P., Sournia, G., and Wangary, E. (eds.) 1987. *Pour une stratégie sahélienne de gestion de faune.* Publication ENDA-UNESCO MAB-UICN. 145pp.

Pierre Pol Vincke, Cellule Après-Barrage, c/o Ambassase de Belgique, Dakar, Senegal. Ibrahim Thiaw, IUCN Africa Programme, Rue Mauverney 28, CH-1196 Gland, Switzerland.

Traditional systems of water resource use and their role in protected area management

WILLIAM M. ADAMS

Management of wetland protected areas in both industrialised and less-developed countries emphasises the importance of established procedures of understanding, modelling and managing water resources. In the Third World, indigenous systems of water resource use provide an alternative approach to wetland management. Indigenous uses include fishing, seasonal pastoralism and agriculture. Wetland agriculture can range from flood-cropping (e.g. of rice) and flood-recession cropping to irrigation at various scales. This paper describes the nature of human economic use of wetlands and the forms and extent of indigenous water management. It concentrates in particular on floodplain wetlands in the semi-arid tropics. The paper explores the common interests between indigenous people using wetland environments and those of protected area management. It argues that both indigenous wetland management and wetland protected areas require maintenance of hydrological regimes and the ecosystems they support. Indigenous systems of wetland resource use are frequently sustainable and compatible with many aims of protected area management, particularly in buffer zones. Wetland people and wetland protected areas depend equally on political decisions about the management of hydrological systems and river basins. The economic value of indigenous production systems can be a strong argument in favour of sustainable hydrological systems management in debates about river basin development.

RIVERS IN the semi-arid tropics have strongly seasonal flooding patterns, with high flows in the wet season and extensive flooding, and low flows in the dry season. Rivers and the extensive flooded wetlands around them support human communities engaged in agriculture, fishing or livestock husbandry. Wetlands provide a range of resources for human use, and provide what are effectively 'free' services. They result from the interconnection of geomorphological, hydrological and ecological processes. These include recharge of regional aquifers and flood control. Wetlands also provide a range of goods, such as water supplies, forage and hunting resources, wood resources, grazing, fish and agricultural produce. Furthermore, a single wetland may produce a number of these outputs at the same time, or serve different communities in different ways through a year. There are, for example, extensive seasonally-flooded wetlands in the Delta Intérieure of the River Niger in Mali and Lake Chad (on the border between Niger, Chad, Cameroon and Nigeria), the Sudd in Sudan and the Okavango Delta in Botswana. There are also countless smaller wetlands along seasonally flooded rivers (for example in Africa the Senegal, Niger, Logone-Chari and Zambezi) and in estuarine environments (for example the deltas of the Senegal in West Africa, and the Tana, Rufiji and Zambezi in the East).

Various types of floodplain are recognised (Welcomme 1979). Fringing floodplains alongside river channels occur on most African rivers. Those along the Niger and Senegal Rivers in West Africa are particularly well-studied. The Senegal covers some 5,000 km² in flood, and shrinks to 500 km² in the dry season. The fringing floodplain of the Niger covers about 6,000 km² in the flood season, shrinking to about half that at low water. Fringing floodplains also occur widely elsewhere, for example in places on the Zambezi and on the Pongolo, Rufiji, Tana and Jubba Rivers in East Africa, and on the Nile.

There are internal deltas on the Niger in Mali, the Kafue in Zambia and on the Chari-Logone system in Cameroon. The Niger Inland Delta extends to 20,000–30,000 km² in the flood season, shrinking to 4,000 km² at low water. In the Kafue Flats in Zambia the area flooded varied from 28,000 km² in the wet season to 13,000 km² in the dry season. The Logone-Chari system is extremely complex, with extensive fringing floodplains as well as extensive flooding where the water enters Lake Chad (the Yaérés Delta). In all, flooding covers some 90,000 km², of which only 7% remains wet at low water.

There are permanent swamp systems in a number of parts of Africa, notably on the White Nile in the Sudd (permanent flooded area 10,000 km²), the Okavango Delta in Botswana (16,000–20,000 km² at high water, 3,000 km² at low water) and on the Shire River draining Lake Malawi. There are coastal deltaic floodplains of particular importance on the Senegal (8,000 km²) the Niger (36,260 km²) and the Zambezi. Although it is so massive, the River Zaire has very little floodplain because its flow is relatively unseasonal, although there are some areas of swamp.

Floodplain hydrology

The seasonal discharge pattern of the rivers of semi-arid Africa (i.e. not including rivers such as the White Nile and the Zaire which drain primarily humid areas) involves high water levels during the flood period. Water overflows the river banks onto the floodplain of the river, often causing widespread inundation. The area inundated then falls with the river hydrograph, until in the dry season some rivers can be reduced to pools of water separated by dry land. The timing and duration of flooding varies downstream. In the upper reaches of a river floodplains tend to be narrower, and there is quite a quick response to rainfall. Floods tend to have a sharper peak, and shorter duration. Further downstream, floodplains are larger and have a more complex form. Floods tend to be slower to begin, longer, and later to end. On the Niger River, for example, the flood peak moves downstream at about 17 km per day, taking over 100 days to travel the 1,760 km from Koulikoro to Malanville (Welcomme 1979).

Flooding is also affected by local rainfall, particularly in flooding backswamp areas and pools. In deltaic environments tidal movements can be important, backing up river flows and enhancing freshwater flooding. This is a significant factor in the flood-related agriculture of the Senegal floodplain and the Basse Casamance in West Africa. Local runoff into the floodplain also provides a vital source of water for irrigation in areas such as the Basse Casamance which are subject to brackish or salt tidal influence.

Floodplain economics

In dryland Africa, the economic importance of wetlands is very great. This can include direct production of surplus food or other commodities or simply providing sound and sustainable incomes in both good and bad years for fairly large numbers of people. IUCN research on the The Niger Inland Delta, for example, shows that it supports some 550,000 people, and in the dry season provides grazing for about 1 million cattle and 1 million sheep and goats. There are some 80,000 fishermen, and the delta supports some 17,000 ha of rice, half the total area of rice in Mali.

In many instances, economic use of wetlands is integrated closely with that of surrounding drylands. In Sierra Leone the cultivation of swamp rice and dryland crops are closely integrated. Dryland and wetland crops require labour at different times of year, and by exploiting the two environments, farmers are able to stretch over bottlenecks in labour supply, while at the same time making use of two separate environments and thus spreading risks (Richards 1986). Pastoralists also use wetlands seasonally, concentrating onto seasonally-flooded land as surrounding rangelands dry out. In this instance, a relatively small area of wetland provides support for grazing at critical times of year, and supports this activity through the rest of the year over a much larger area. For example, the Peul of the central Senegal Valley move away from the floodplain with their livestock in the wet season, but come back to farm when the floodwaters recede from the valley in the dry season (Léricollais and Schmitz 1984). Integration of valley and upland environments is one of the three basic features of indigenous agriculture in West Africa (Richards 1983).

Floodplain agriculture

Data published by the FAO Investment Centre (FAO 1986) suggest that almost half the irrigated area in sub-Saharan Africa lies in the 'small-scale/traditional' sector. The report identifies a total of 5.02 million ha of irrigation in sub-Saharan Africa, of which 2.38 million ha (47%) are 'small-scale or traditional'. This category is diverse. It includes flood cropping, small earth dams, small run-of-river diversions, pump irrigation from wells or open water and water harvesting. FAO estimates that only 200,000 ha of the total 2.38 million ha is irrigated by what they call 'modern or intensive private operators'. The rest (92%) is land irrigated by 'traditional private operators'. This gives some measure of the strength of indigenous irrigation in Africa. Much of that takes place in floodplains, swamps and deltas.

Flood cropping in Africa embraces a number of distinct practices. These include farming on the rising flood (crue), on the falling flood (décrue) and farming systems which involve defence against salt water in coastal environments. Cultivation on the rising flood involves planting before the flood arrives (rice often germinating with the arrival of the rains), and harvesting either from canoes or after the flood has fallen. Décrue agriculture involves the use of residual soil moisture left by retreating floods. Floodplain soils often contain clay, and retain water well. Furthermore, water is usually left in backswamp areas and pools long after the river level has fallen. These can be enhanced by human-made bunds to retain water. Farmers become adept at

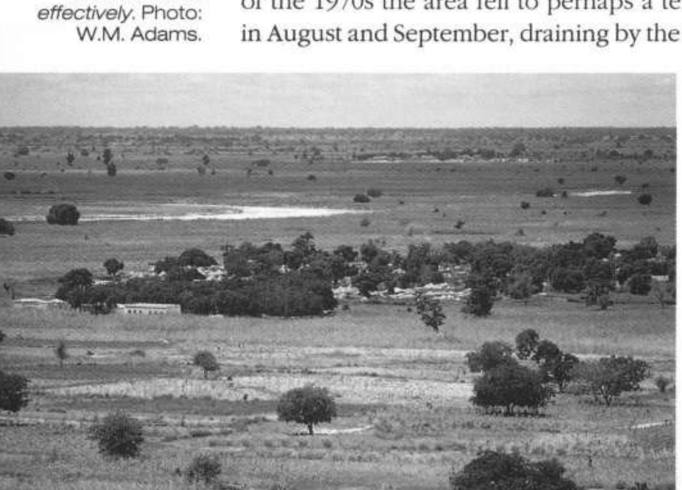
Décrue agriculture in the Senegal River delta.
Photo: X. Cogels.

judging the likely duration of water and soil moisture in these areas, and choose crops and crop varieties that suit expected soil and water conditions. Bunds are also used in estuarine environments such as the Basse Casamance in Senegal, to keep brackish water off rice fields (Linares 1981).

Flood cultivation is a high-risk high-return activity. Floodplain wetlands are highly productive in ecological terms compared to the drylands which surround them. Their productivity is partly because the floodwaters go some way to meeting evaporative demand, and hence allow plant growth for a longer period. Plants in floodplains are therefore able to use more of the available solar energy, and their productivity is higher. Indeed, tropical swamps are among the most productive ecosystems on earth. In addition, floodplain wetlands are fertile. The annual inundation involves the deposition of silt and other solid material carried by rivers, and the dissolved load of the floodwater. The Logone-Chari River loses 20–60% of its suspended load and 15–35% of its dissolved load when it inundates its floodplain in Cameroon. This can allow continuous cropping in such wetland environments, without the fallowing which is so widely necessary in drylands.

Floodplain farmers often possess detailed knowledge of crop ecological requirements and flooding patterns and the variation in land types in the floodplain. Farmers in floodplains not only tackle risk by applying their knowledge of environment and environmental variability, but also spread their options into different economic activities. In most cases, floodplain farmers are also fishermen, herders or dryland cultivators; sometimes all three. Just as the wetland provides an additional option for dryland farmers in times of drought, dryland agriculture can provide an important fall-back for wetland farmers in times of flood. Indigenous environmental and agronomic knowledge and the spreading of risk through exploitation of environments outside as well as inside the wetland is part of what Paul Richards calls a 'rolling adjustment' to nature (Richards 1985, 1986).

Floodplain cropping is widespread in West Africa. The fringing floodplain of the River Senegal downstream of Bakel covers about 1 million ha, of which in the 1960s (when rainfall was good) about 150,000–200,000 ha were cultivated. With the drought of the 1970s the area fell to perhaps a tenth of that. The lower Senegal River floods in August and September, draining by the end of December or January. The floods are thus out of synchrony with the rains (June–September), and the floodplain is cultivated in the dry season using the floodwater and the residual soil moisture in the floodplain soils (Léricollais and Schmitz 1984, Boutillier and Schmitz 1987, Schmitz 1986).



Intensively cultivated floodplain in the Sokoto Valley, Nigeria. Crops are selected by farmers to optimise soil and water conditions across the floodplain. Changes to established flooding patterns (volume or timing) interfere with farmers' abilities to exploit these floodplain environments effectively. Photo: W.M. Adams.

Flood-related cropping in fringing floodplains is not restricted to West Africa, although it is true that it is most extensive, and best studied, there. It has been recorded in the Omo Valley in Ethiopia, the Tana River Valley in Kenya, the Rufiji in Tanzania, the Zambezi and the Lufira in Zaire. Flood-recession agriculture is also practised in the molapos of the

Okavango Delta, Botswana, and the floodplain of the Pongolo River in Natal. In few cases have detailed studies been carried out, but the general principles are familiar: integration of wetland and dryland resources, dependence on seasonal flooding regimes and recognition of different land types and associated flood patterns. The Tonga on the banks of the Zambezi, for example, recognise five garden types. Two are only used in the rainy season (unda and temwe), a third (kalonga) lies in damp areas in small stream valleys and two more (jejele and kuti) involve flood-recession cropping. Jejele land on the banks of the river is cultivated as floods decline, and may in parts be double-cropped.

In the valley of the river Sokoto in Nigeria, farmers have a shrewd idea of what depth and duration of flooding to expect on different parts of the floodplain, and they recognise a range of crop varieties suited to different conditions. In the Sokoto case the river floods in synchrony with the rains, and cultivation on floodplain land (like other seasonally damp land called fadama in Hausa) was closely integrated with dryland farming and all the other economic activities available. All farmers had access to rainfed land, but not all to floodplain land. Those farmers (almost all of whom were Hausa people) grew several named varieties of rice as well as sorghum varieties which were resistant to flooding. In the Sokoto floodplain these crops were typically followed by a second cycle of cropping in the dry season, often on deeper-flooded land not available in the rains. This 'aikin rani' (literally 'dry season work') was widespread and intensive, and often involved the use of wells and sometimes shadoofs (simple irrigation devices using a bucket and counter-balance on a long beam) to extend the growing season. Wells with buckets are a laborious form of irrigation, and water can only be lifted about 2–3 metres. It is, however, a widespread practice in Africa, for example to irrigate shallots on raised beds in the Volta Delta (Chisholm and Grove 1985) and in the dambos (shallow linear depressions in the headwater zone of a river basin, lacking a stream channel) of the communal areas in Zimbabwe (Turner 1986).

In places, notably northern Nigeria, human-powered water lifting for irrigation is being rapidly replaced with small motor-powered pumps. These are portable and relatively inexpensive. Petrol is relatively plentiful in Nigeria, and the pumps use a comparable technology to that of small motorcycles, and so can easily be maintained. Although there are problems with this technology (e.g. a shortage of spares), through the late 1980s there was a major small-scale irrigation boom in suitable environments in northern Nigeria (Kimmage and Adams 1990). It seems that given the right technology, and the right economic environment, long-established indigenous wetland production systems can be rapidly modernised – in this instance with minimal input from formal 'development' initiatives.

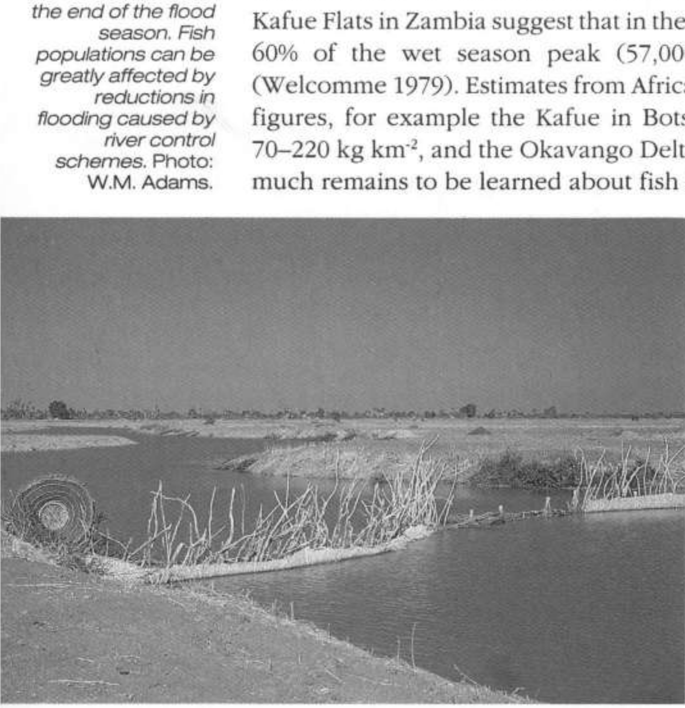
Traditional dry-season irrigation using a shadoof. Photo: W.M. Adams.

Floodplain fishing

Fish production is a basic element in the economy of many African wetlands, particularly inland lakes and various kinds of floodplains. FAO estimate that there are over 60,000 fishermen on the Niger River (50,000 fishermen in the Niger Inland Delta, plus another 6,000 on the River Niger in Niger and Nigeria, and 5,000 on the Benue), and that together they produce 120,000 tonnes per year, of which 75% comes from the Niger Inland Delta. The life-cycle of many fish species is linked to seasonal flood regimes. The inundated floodplain is rich in nutrients, and local runoff sweeps further nutrients into the floodwaters. As a result there is rapid growth of aquatic vegetation and a bloom of microorganisms and growth in invertebrate numbers. This provides plentiful food for fish, and in many species reproduction is timed so that they spawn when rivers are in flood. Not only is food varied and abundant, but there is a measure of protection from predators. Young fish grow rapidly. Fish making a movement of this kind into the floodplain are said to undergo lateral migration. They may move upstream a short distance before dispersing into the floodplain, although tagging experiments show that some fish will move substantial distances. For example, fish move up the Logone-Chari system from Lake Chad to spawn.

As floods fall adult and young fish move back to the main river channel, and eventually to standing pools where they survive the dry season. There is significant predation both from fishing people and animal predators (particularly birds and other fish) at this time of year. Some species, such as the lungfish and some catfish, are well-adapted to surviving conditions low in oxygen through the dry season. Not all species breed in one go in the floods. Some species, such as the cichlids which brood their young in their mouth, lay eggs in small batches, and usually start before the floods rise. Others (e.g. small clupeids), which feed on zooplankton, spawn in pools on the falling flood when zooplankton is most abundant.

The amount of fish in a floodplain will obviously vary very greatly through the season. It will be lowest at low water. Studies by the University of Michigan in the Kafue Flats in Zambia suggest that in the dry season the biomass of fish falls to about 60% of the wet season peak (57,000 tonnes as opposed to 96,000 tonnes) (Welcomme 1979). Estimates from African floodplains give a wide range of biomass figures, for example the Kafue in Botswana 44 kg km^{-2}, the Chari in Cameroon 70–220 kg km^{-2}, and the Okavango Delta in Botswana 20–70 kg km^{-2}. It is clear that much remains to be learned about fish biology and ecology, and about floodplain fisheries. Nonetheless, two things are clear: first the high productivity of floodplain wetlands, and second the close links between that productivity and the flood regime. That relationship is confirmed by research on the impacts of reduced floods on recruitment of fish dependent on floodplain inundation, and the slump in fish landings in the Senegal River and Niger Inland Delta during the drought of the 1970s.



A barrier fish trap in the Hadejia-Jama'are Floodplain Wetlands, northern Nigeria. These traps can make large catches as fish return from the inundated floodplain to river channels at the end of the flood season. Fish populations can be greatly affected by reductions in flooding caused by river control schemes. Photo: W.M. Adams.

Floodplain grazing

African wetlands also play an important role in sustaining dryland grazing systems. Many wetland people combine agriculture with either herding or fishing, sometimes both. Thus in the Niger Inland Delta in Mali there are about half a million people, a mixture of farmers, fishing people and pastoralists (Moorehead 1990a, 1990b). There are five main groups. In the upstream parts of the delta there are people who primarily fish. They do grow crops, but they leave their fields as the floods start to fall and migrate through the delta to end up in the deep lakes of the north-east (Debo and Walado) at the end of the dry season. In this area are a second group of fisher/farmers who grow deep-water rice in the flood season and move much shorter distances to fish as the floods recede. In addition to this, there are sedentary farmers, and two groups of pastoralists.

The climate of the delta is dry (200–700 mm rainfall) and strongly seasonal, as one would expect of the Sahel. The River Niger is also seasonal, with discharges varying from 70 m^3sec^{-1} in May to 5,000 m^3sec^{-1} in October. The annual mean is 70 billion m^3, almost half of which is lost in evaporation, evapotranspiration and infiltration to groundwater within the delta. The productivity of the delta depends on the fact that the period of high flood is different from that of the local rains because the Niger draws water from the Futa Jallon far to the south-west. The rains fall on the delta between June and September. During this period the floods rise, peaking after the end of the rains, between October and December. The floods fall between January and March, and the delta is dry between April and June. The delta is extensively used for grazing between December and July. It supports over 1 million head of cattle and 2 million sheep and goats, 20% of the total numbers in Mali.

Fulani pastoralists are resident in the Delta, while Tuareg only move in during the dry season. The Fulani leave the floodplain as the rains begin, to graze livestock in savanna grasslands. As grazing resources and water supplies run out, they move back into the delta floodplains and graze livestock on the pastures emerging from the floodwaters. In February/March their stock are grazing the dry lake beds in the north of the delta, particularly on "bourgou" *Echinochloa stagnina*, a grass growing in floodwater. This provides an abundant volume of forage, although of low nutritive value. The Tuareg are allowed onto the floodplain pastures later than the Fulani. The use of the delta grasslands allows a remarkably constant supply of grazing resources. Research on cattle herds elsewhere in Mali and in the Sudan suggests that most calves are conceived in the wet season, and that as a result milk supply is episodic within the year (Drijver and Marchand 1985). In the Niger Inland Delta, the availability of forage and skilful herd management maintain milk supply through the year.

References

Adams, W.M. 1986. Traditional agriculture and water use in the Sokoto Valley, Nigeria, *Geographical Journal* 152: 30–43.

Adams, W.M., and Hughes, F.M.R. 1986. The environmental impacts of dam construction in Tropical Africa: impacts and planning procedures. *Geoforum* 17(3): 403–410.

Adams, W.M. 1990. *Green Development: environment and sustainability in the Third World.* Routledge, London.

Adams, W.M. 1990. Definition and development in Africa indigenous irrigation, *Azania* xxiv: 21–27.

Adams, W.M. 1992. *Wasting the Rain: use and misuse of rivers and wetlands in Africa.* Earthscan, London.

Boutillier, J-L., and Schmitz, J. 1987. Gestion traditionalle des terres (système de Décrue/ système pluvial) et transition vers l'irrigation. *Cahiers Sciences Humaine* 23: 533–554.

Chisholm, N.G., and Grove, J.M. 1985. The lower Volta, pp. 229–250 in A.T. Grove (ed.) *The Niger and its Neighbours: environmental history and hydrobiology, human use and health hazards of the major West African rivers.* Balkema, Rotterdam.

Drijver, C.A., and Marchand, M. 1985. *Taming the Floods: environmental aspects of floodplain development in Africa.* Centre for Environmental Studies, University of Leiden.

Dugan, P.J. (ed.) 1990. *Wetland Conservation: a review of current issues and required action*, International Union for the Conservation of Nature, Gland, Switzerland.
FAO. 1986. *Irrigation in Africa south of the Sahara*. Investment Centre and Land and Water Division, FAO, Rome (Report 111/85 CP-SSA).
Goldsmith, E., and Hildygard, N. 1984. *The Social and Environmental Effects of Large Dams; Volume 1, Overview*. Wadebridge Ecological Centre, Wadebridge, Cornwall, UK.
Kimmage, K., and Adams, W.M. 1990. Small-scale farmer-managed irrigation in northern Nigeria, *Geoforum* 21: 435–454.
Linares, O.F. 1981. From tidal swamp to inland valley: on the social organisation of wet rice production among the Diola of Senegal, *Africa* 51: 557–595.
Lowe-McConnell, R.H. 1985. The biology of the river systems with particular reference to the fishes. In: Grove, A.T. (ed.) *The Niger and its Neighbours: environmental history and hydrobiology, human use and health hazards of the major West African rivers*. 101–140. Balkema, Rotterdam.
Léricollais, A., and Schmitz, J. 1984. La Calabasse et la Houe: techniques et outils des cultures de décrue dans la vallée du Sénégal. *Cahiers ORSTOM Série Sciences Humaine* 20(3–4): 427–452.
Moorehead, R. 1990a. Access to resources in the Niger Inland Delta, Mali. In: Seeley, J., and Adams, W.M. (eds.) *Environmental Issues in African Development Planning*. 27–39. African Studies Centre Cambridge, Cambridge African Monographs 9.
Moorehead, R. 1990b. *Land tenure and environmental conflict: the case of the Inland Niger Delta, Mali*. Unpublished paper, March 1990.
Richards, P. 1983. Farming systems and agrarian change in West Africa. *Progress in Human Geography*, 7(1): 1–39.
Richards, P. 1985. *Indigenous Agricultural Revolution*. Hutchinson, London.
Richards, P. 1986. *Coping with Hunger: hazard and experiment in a West Afrtican rice-farming system*. Allen and Unwin, Hemel Hempstead.
Salau, A.T. 1985. River basin planning as a strategy for rural development in Nigeria. *J.Rural Studies* 2: 321–335.
Scudder, T. 1962. *The Ecology of the Gwembe Tonga*. Manchester University Press, Manchester, for the Rhodes-Livingstone Institute, Kariba Studies Volume II.
Scudder, T. 1989. *The African Experience with River Basin Planning*. Westview Press, Boulder, Colorado.
Seignobos, C. 1984. Instruments aratoires du Tchad Méridional et du Nord-Cameroun. *Cahiers ORSTOM Sér. Sci. Hum.* 20: 537–575.
Schmitz, J. 1986. Agriculture de décrue, unités térritoriales et irrigation dans la valée du Sénégal. *Les Cahiers de Recherches Développement* 12: 65–77.
Turner, B. 1986. The importance of dambos in African agriculture. *Land Use Policy* 3: 343–347.
Welcomme, R.L. 1979. *Fisheries Ecology of Floodplain Rivers*. Longman, London.

Dr W.M. Adams, Department of Geography, University of Cambridge, CB2 3EN, UK.

Legal brief

The African-Eurasian Agreement on the Conservation of Migratory Waterbirds

MICHAEL MOSER, JANINE VAN VESSEM AND PAUL GORIUP

The first negotiation meeting for the African-Eurasian Agreement on the Conservation of Migratory Waterbirds, under the Bonn Convention on Migratory Species (CMS), took place in Nairobi in June 1994 (see PARKS Vol. 4 no. 1). Now, just one year later, it is pleasing to report that the final negotiation session for this Agreement took place in The Hague (Netherlands) from 12 to 16 June 1995, leading to the signature of the Final Act by 54 of the 64 range states' representatives.

Since the Nairobi meeting, intensive work had been undertaken by the CMS Secretariat, the Dutch Government, the Environmental Law Centre of IUCN – The World Conservation Union, and the International Waterfowl and Wetlands Research Bureau (IWRB) to prepare the final draft text of the Agreement on African-Eurasian Migratory Waterbirds (AEWA) and its associated Action Plan, which were the subject of the most recent meeting. Although the AEWA text had been previously discussed in detail, the Action Plan had not been the subject of any formal negotiations. Nevertheless, the Action Plan was adopted as a legally binding text, together with the AEWA, thanks to the willingness of all range states to reach a successful conclusion. The AEWA opened for signature on 16 October 1995. To enter into force it requires seven Eurasian and seven African states to ratify it.

Development of the AEWA proposal

Development of the AEWA originally started with work on a less extensive "Western Palearctic Waterfowl Agreement". The first meeting of the Conference of the Parties to the Bonn Convention (Bonn, 1985) passed a resolution calling for the development of an Agreement for Western Palearctic Anatidae (ducks, geese and swans). An early draft of such an Agreement was drawn up during 1988–1991 by the government of the Netherlands, acting on behalf of the European Economic Community (EEC), in collaboration with the CMS Secretariat, IUCN, a Working Group of the CMS Scientific Council and IWRB. In 1992 the CMS Secretariat began an initiative to conclude a broader Agreement as part of a global strategy, by incorporating other work on storks, ibises and spoonbills, and updating the content of the legal text.

As a result, a draft AEWA text and associated actions were published in September 1993. These were discussed by the range states and major international NGOs in June 1994, in Nairobi, Kenya, following the Fourth Meeting of the Conference of the Parties to the Bonn Convention.

Purpose and scope of the AEWA

The Bonn Convention intends to establish an international network for the conservation of migratory animals over the whole of their range. The proposed

AEWA, as a particular instrument of the CMS, pursues the same goal with regard to migratory waterbirds, namely to create the legal basis for a concerted conservation policy of the range states of migratory waterbird species and populations, individuals of which migrate in the Western Palearctic and Africa, irrespective of their current conservation status. The Agreement Area covers the entire continents of Africa and Europe, as well as parts of Asia and a few Arctic islands of north-eastern Canada, encompassing 116 range states. It includes 172 species of migratory waterbirds. A number of these have been identified as being of particular importance for early attention: they are listed in an Action Plan appended to the Agreement. At a later stage the Action Plan will be extended to all other species covered by the AEWA with particular regard for those species which are endangered or have an unfavourable conservation status.

To achieve the purpose of the AEWA means focusing attention on breeding grounds as well as on moulting, resting and wintering areas and on the major flyways. The scope of the task requires a wide variety of conservation and management problems to be considered, including:

- Strict legal protection by the range states of those migratory waterbirds that are endangered.
- Appropriate legal protection of those migratory waterbirds that have an unfavourable conservation status.
- Establishment of a coordinated and harmonised system for conservation of migratory waterbirds in the range states of the AEWA.
- Conservation of suitable habitats and maintenance of their network throughout the entire range of these birds.
- Sustainable utilisation of the migratory waterbirds and their habitats.
- Concerted and interactive monitoring of migratory waterbirds.
- Active research and public awareness programmes.

White storks Ciconia ciconia *feeding on wheat stubble near Lake Nakuru in Kenya. This species is covered by conservation measures set out in the AEWA Action Plan.* Photo: P. Goriup/Pisces Nature Photos.

In order to obtain the most favourable and efficient results, the Agreement provides the following guidelines:

- Specific potential threats and the factors that have led to the reduction in numbers of any of the migratory waterbird species concerned should be investigated by developing conservation plans for the whole area of their migratory route.
- The results of conservation plans for different species' migratory routes which more or less overlap should be compared with each other.
- Countries, regions and sites which show similar and significant needs to conserve a multitude of species should be identified.
- Immediate efforts should be concentrated on conservation measures that have priority.

- Extensive projects, such as those involving habitat management and restoration, should be carefully planned and implemented through integrated measures. They should aim to alleviate the pressure for habitat exploitation, while also creating a positive attitude among the people living in the area concerned by bringing them alternative benefits to those they had from this exploitation. Such benefits would comprise, among others, improvement of the transportation infrastructure, development of a regional economy in an ecologically-friendly manner, and establishment of new jobs.
- The administrative and financial burden of the conservation measures should be shared by the international community for the sake of the overall interest to preserve migratory waterbirds as a part of the world's heritage of biodiversity.

In general, the AEWA provides for the instruments, which, if applied in an efficient manner, would present a sound basis for the organisation and financing of projects aimed at the conservation of migratory bird species.

Relation to other conventions

It may appear that the proposed AEWA overlaps or even competes with other conventions, such as the Ramsar and Biodiversity Conventions. The AEWA, however, is specifically aimed at migratory waterbirds, and defines international standards for their conservation and sustainable utilisation within the whole of their migration range. The other conventions provide partial protection for migratory waterbirds, but they all have some limitations with regard to this particular group of species.

The Ramsar Convention provides primarily for the rational use of extended wetland ecosystems with large numbers of species or individuals. This is important but not sufficient for the effective conservation of those migratory waterbirds that use less extensive or scattered sites, and require a different conservation strategy. The Convention on Biological Diversity (CBD) seeks to cover all biodiversity globally, emphasising the sovereign right and responsibility of States to conserve and use biodiversity within their territories. It is very general and, although including migratory species as a whole, it does not provide the specific instruments and mechanisms necessary for their effective conservation. In fact, the CBD urges its Contracting Parties to participate in international cooperation through membership in specialised global and regional conventions and the conclusion of regional or multilateral arrangements.

The AEWA is, therefore, highly complementary to these conventions, rather than competitive. The best results can be expected through integrated implementation at international and national levels of all these international instruments, each covering its specific field, and so providing an effective nature conservation network on a global scale. Indeed, the CMS Secretariat and the interim AEWA secretariat will seek areas for concerted activities with the Ramsar Bureau and the Secretariat of the Convention on Biological Diversity.

Benefits of joining the AEWA

During the Fourth Meeting of the Parties to the Bonn Convention and the subsequent First Intergovernmental Session on the AEWA in Nairobi in June 1994, it became clear that a novel strategy for implementing the AEWA would be needed if it was to foster support and enthusiasm from the Parties.

The CMS Secretariat is already considering a preliminary strategy that will form a major part of the work programme for the interim secretariat of the AEWA, and provide a platform for seeking funding from appropriate international institutions. Within this framework, a Party to the AEWA could benefit in many ways, such as:

- International recognition for its commitment to conservation of migratory waterbirds, which also represents a contribution to the implementation of the Biodiversity Convention.
- Participation in training, public awareness and research programmes aimed at the conservation of migratory waterbirds and their habitats.
- international support for wetland management initiatives at important sites.

AEWA Action Plan

The Action Plan prioritises actions for biogeographical populations of waterbirds according to their conservation status, and the meeting unanimously approved a set of quantitative criteria to allow classification of the species into three broad categories. Given the paucity of knowledge for many of the populations, the criteria are largely based on count data, incorporating absolute population estimates, trends, and measures of vulnerability. The meeting emphasised the need to improve the trend data for use in assessing conservation status, and recent developments of the International Waterfowl Census are moving rapidly in that direction.

The selection of quantitative criteria is going to provide an extremely useful tool for the future, which will be objective, easy to apply and understand, and which will allow species to move in priority according to their conservation status.

Key points in the Action Plan include:

- A careful regulation of hunting according to the conservation status of each population, recognising the positive role that hunting can play in the conservation of habitats.
- The preparation and implementation of single species action plans for species with the poorest conservation status.
- Development of emergency measures.
- Re-introduction programmes.
- Measures to address problems raised by introduced species.
- Habitat inventories, conservation and management measures (linked closely to the Ramsar Convention).
- Management of various human activities including hunting, ecotourism, crop damage conflicts etc.
- Development and coordination of research, monitoring, awareness and training programmes.

A key action which is envisaged in the first Action Plan is the preparation of a series of Conservation Guidelines and reviews, which will help the Parties to determine priorities and best-practice measures for dealing with particular problems.

The AEWA stresses the need for improved monitoring of wetlands. Photo: P. Gorup/ Pisces Nature Photos.

Agreement secretariat

A key element for the success of the AEWA will be an active secretariat. Generously, the Dutch government offered to provide an interim secretariat, at no cost to the other Parties, for the first three years. It will aim to reach the ratification target as soon as possible, and encourage range states to address some of the key issues described above even before full ratification. Following this, it is proposed that the AEWA secretariat would move to Bonn, to be co-located with the Bonn Convention Secretariat.

The AEWA is an important piece of international legislation which, together with the Ramsar Convention, provides a very comprehensive mechanism for conserving migratory waterbirds and their wetland habitats throughout the African-Eurasian region.

Michael Moser and Janine van Vessem, IWRB, Slimbridge, Gloucester, GL2 7BX, UK.
Paul Goriup, Nature Conservation Bureau, 36 Kingfisher Court, Hambridge Road, Newbury, RG14 5SJ, UK.

IUCN - The World Conservation Union

Founded in 1948, The World Conservation Union brings together States, government agencies and a diverse range of non-governmental organisations in a unique world partnership: over 800 members in all, spread across some 125 countries.

As a Union, IUCN seeks to influence, encourage and assist societies throughout the world to conserve the integrity and diversity of nature and to ensure that any use of natural resources is equitable and ecologically sustainable.

The World Conservation Union builds on the strengths of its members, networks and partners to enhance their capacity and to support global alliances to safeguard natural resources at local, regional and global levels.

IUCN, Rue Mauverney 28, CH-1196 Gland, Switzerland
Tel: ++ 41 22 999 0001, fax: ++ 41 22 999 0002,
internet email address: <mail@hq.iucn.ch>

Commission on National Parks and Protected Areas (CNPPA)

CNPPA is the largest worldwide network of protected area managers and specialists. It comprises over 800 members in 150 countries. CNPPA is one of the six voluntary Commissions of IUCN – The World Conservation Union, and is serviced by the Protected Areas Programme at the IUCN Headquarters in Gland, Switzerland. CNPPA can be contacted at the IUCN address above.

The CNPPA mission is to promote the establishment and effective management of a worldwide network of terrestrial and marine protected areas.

Resumenes

El efecto de la reducción de las inundaciones dentro y fuera del Parque Nacional Waza, Camerún

M.N. TCHAMBA, C.A. DRIJVER Y H. NJIFORTI

Aproximadamente 6,000 km^2 de las planicies naturales del Río Logone en Camerún del Norte constituyen un importante ecosistema de humedales del Sahel. Parte de las planicies inundadas están protegidas como parque nacional y contienen poblaciones de elefantes, jirafas, leones y una rica y variada avifauna. Las planicies inundadas son un sistema tradicional sustentador de vida para las comunidades humanas que dependen de las inundaciones naturales para mantener a su ganado, pesquerías, arrozales y agricultura recesiva. Especialmente durante la época de secas, sus frescas pasturas son esenciales para la supervivencia de grandes cantidades de ganado.

En años recientes, el ambiente en las planicies de Logone ha cambiado considerablemente. Los crecientes números de personas y ganado, combinadas con la sucuencia de crecientes sequías y la creación de proyectos de arroz a gran escala, han resultado en la degradación de los recursos y en problemas ambientales.

La reducida profundidad de las inundaciones ha dado como resultado la muerte de los pastos en las planicies inundadas con consecuencias sobre la productividad de la vida silvestre y el ganado. Las pesquerías y el cultivo tradicional de arrozales también han sido afectadas severamente. El daño a los campos de cultivo causado por elefantes ha aumentado. Durante los años de sequía (desde 1985) vidas humanas han tenido que ser salvadas por migración y por alimentos donados. La sobre-explotación ha resultado en mayor degradación.

La rehabilitación hidrológica de las planicies inundadas de Logone ha sido investigada como parte del Proyecto Waza Logone. Posibles medidas basadas en el conocimiento acutal son: apertura del terraplén con el objetivo de reconectar a las planicies inundadas con el río Logone; descarga controlada de aguas del Lago Maga combinado con un aumento de flujo del Logone al Lago Maga; y la posibilidad de rehabilitar a los riachuelos y canales que se usaban para transportar agua hacia la planicie.

El manejo de los recursos del agua en el delta del Río Indo, Paquistán

PETER-JOHN MEYNELL Y M. TAHIR QURESHI

Durante los últimos 40 años, el Río Indo ha sido progresivamente contenido por presas y sus aguas han sido desviadas para irrigación, para generación de electricidad y para proveer agua para usos doméstico e industrial. El flujo promedio anual en el Indo era de cerca de 150 millones de acres pies (MAP), de los cuales alrededor de 105 MAP (i.e. 5,850 $m^3 sec^{-1}$) son extraídos cada año, y cerca de 35 MAP son descargados de la presa más baja en el río. Solo cerca de 20 MAP alcanzan a llegar al delta y por nueve meses del año, no existe flujo alguno de agua dulce. Se ha reconocido en recientes acuerdos de distribución de aguas entre las Provincias de Paquistán, que por razones ambientales se deben descarger un mínimo de 10 MAP al delta. La irrigación sin adecuado drenaje ha resultado en la perdida de tierras agrícolas por la anegación y la hipersalinidad del suelo. Se pierde cerca de la mitad del agua desviada para irrigación antes de que esta llegue a los campos debido a la filtración, evaporación e ineficacia del sistema. La intrusion de salinidad del delta en el agua subterránea se esta convirtiendo en un problema serio en la parte baja del Indo. La reducción progresiva del flujo de agua dulce ha tenido un efecto sobre la salinidad en los riachuelos del delta (a menudo la salinidad excede 45 partes por mil). Esto pone bajo presión a los manglares causando enanismo y perdida de plantas jóvenes. La supervivencia del ecosistema de manglar está corriendo riesgos.

Asimismo, la reducción del sedimento descargado, de 400 millones de toneladas por año a menos de 100 millones de tonelades actuales y probablemente más bajas en el futuro, tiene implicaciones sobre la geomorfología del delta. Aunado esto al aumento en el nivel del mar, pudiera resultar en el allanamiento y la erosión del delta proporcionando menor protección costera contra las fuerzas del monzón del sur-oeste. La reducción en el sedimento proveniente del suelo de los bancos significará que el manglar no podrá soportar niveles más altos en el mar. Es improbable que haya mayores descargas de agua dulce o de sedimento río abajo del Indo en el futuro como resultado de las crecientes

presiones de la población. Las medidas de manejo pudieran incluir la plantación de más especies de manglar tolerantes a la salinidad y la descarga de aguas agrícolas ligeramente salinas.

Protección del bosque de turba pantanosa del norte de Selangor, Malasia

NATHER KHAN

Los suelos de turba ocupan un área total de cerca de 809,000 ha, constituyendo un 6% del total del área superficial de la Península de Malasia. Orginalmente, el área entera probablemente estaba cubierta de bosque; sin embargo, solo 497,276 todavían quedaban cubiertas en 1954. La mayor parte de este bosque pantanoso de turba ha sido talado para dar paso a la agricultura y a la minería de estaño. Aunado a esto, los bosques naturales localizados sobre suelos de turba han sido explotados comercialmente por sus maderas por cerca de 40 años. El efecto acumulativo de estas presiones es la rápida reducción de áreas de bosque primario y el daño a sus recursos naturales y a sus funciones de humedales, particularmente a sus recursos hidrológicos.

El Bosque de Turba Pantanosa del Norte de Selangor, que cubre un área de 75,000 ha, está localizado a lo largo de la frontera oriental del Proyecto de Desarrollo de Agricultura Integral del Noroeste de Selangor, una de las mayores áreas de cultivo de arroz en Malasia. El bosque pantanoso se ha identificado como el más importante pantano de turba el la 'costa occidental' de Malasia y es de importancia nacional e internacional. También se le ha identificado como a uno de los tres humedales con prioridad para implementar su manejo en la Peninsula de Malasia. El pantano también juega un importante papel en la mitigación de inundaciones y como controlador de la contaminación. La tala o el drenaje de éste bosque de pantano de turba podría, entre otras cosas, eliminar una función de almacenamiento temporal que actualmente está beneficiando a la red de irrigación, aumentar el efecto de las inundaciones y la carga de sedimento, afectar la calidad del agua, acelerar la intrusión de salinidad hacia áreas río arriba y hacia proyectos de cultivo de arroz.

Areas protegidas y presa: el caso del delta del Río Senegal

PIERRE POL VINCKE E IBRAHIM THIAW

El Río Senegal ha sido objeto de proyectos de desarrollo de recursos del agua. Se han construido dos presas en el río, uno en Diama, cerca de la boca del río, que fue diseñada para excluir el agua salina; mientras que la otra, situada en Manantali en Mali, es una presa hidroeléctrica.

El desarrollo de la sub-región dependerá de como se manejen estos proyectos. Las investigaciones llevadas a cabo como parte de éste importante esquema han realzado una vez más el problema de las áreas protegidas y su integración en esquemas de desarrollo. Estos estudios han demostrado que su futuro dependerá primeramente en la habilidad de los gobiernos para integrarlos en su planeación, en la manera en que éstos definan sus pólizas de desarrollo basadas en el manejo óptimo de los recursos naturales para sus territorios nacionales (los que también existen fuera de éstas zonas), sobre la habilidad de mantener una atmósfera de cooperación regional fructífera y sobre la manera en que los socios internacionales reaccionen a éstos proyectos.

Se han tomado ejemplos del banco oriental (Mauritania) y del banco occidental (Senegal) del delta del Río Senegal, para ilustrar la situación del ambiente natural del valle y de las políticas ambientales practicadas – ó descuidadas – por los gobiernos interesados.

Sistemas tradicionales de uso del recurso del agua y su papel en el manejo de áreas protegidas

WILLIAM M. ADAMS

El manejo de áreas protegidas de humedales en países industrializados y en desarrollo enfatiza la importancia de procedimientos establecidos para el entendimiento, modelado y manejo de los recursos del agua. En el Tercer Mundo, los sistemas indígenas para el uso de los recursos hídricos proporcionan un enfoque alternativo para el manejo de los humedales. Los usos indígenas incluyen pesquerías, pastoreo de estación y agricultura. La agricultura en los humedales va desde cultivos en las inundaciones (e.g. arrozales) y cultivos en la época de secas hasta irrigación en varias escalas. Este reporte describe la naturaleza del uso económico humano de los humedales y de las formas y extensión del manejo indígena del agua. En particular se concentra en humedales en planicies inundadas en los trópicos semiáridos. El reporte explora los intereses comunes entre los grupos indígenas que usan los ambientes de humedal y aquellos de manejo de áreas protegidas. Se discute que ambos, el manejo indígena de los humedales y los humedales protegidos, requieren del mantenimiento de los regímenes hidrológicos y de los ecosistemas que ellos soportan. Los sistemas indígenas de uso de los recursos de humedales son frecuentemente sostenidos y compatibles con muchos de los objetivos del manejo de áreas protegidas, en particular, de las zonas de amortiguamiento. Los grupos humanos y las áreas protegidas de humedales dependen igualmente de las decisiones políticas acerca del manejo de los sistemas hidrológicos y las cuencas de los ríos. El valor económico del sistema de producciòn indígena puede ser un fuerte argumento a favor de los sistemas hidrológicos de manejo sustentable en debates acerca del desarrollo de cuencas ribereñas.

Résumés

Impact de la réduction des crues à l'intérieur et autour du Parc National de Waza, Cameroun

M.N. TCHAMBA, C.A. DRIJVER ET H. NJIFORTI

Une superficie d'environ 6,000 km^2 de la plaine inondable naturelle du Logone, au nord du Cameroun, constitue un important écosystème de zones humides sahéliennes. Une partie de la plaine inondable, crée en parc national, est protégée et abrite des populations d'éléphants, de girafes et de lions ainsi qu'une avifaune riche et variée. La plaine inondable permet la survie des collectivités humaines traditionnelles qui dépendent de son inondation naturelle pour maintenir leur bétail, leurs lieux de pêche, leur riziculture flottante et leur agriculture de décrue. La présence de nouveaux pâturages, lors de la saison sèche en particulier, est essentielle à la survie d'un grand nombre de bétail.

L'environnement de la plaine inondable du Logone a subi une transformation considérable au cours des dernières années. L'accroissement de la démographie et du cheptel, conjugué à la succession récente de périodes de sécheresse et à la création, à grande échelle, de projets de riziculture, a conduit à une dégradation des ressources et à des problèmes environnementaux.

Une réduction du niveau des inondations a entraîné la disparition des herbages de la plaine inondable, ce qui a des répercussions sur la productivité des animaux sauvages et du bétail. Ceci a eu également des conséquences sérieuses sur la pisciculture et la riziculture flottante traditionnelle. Les dégâts causés aux récoltes par les éléphants et la dégradation des forêts se sont intensifiés. Lors des années de sécheresse (depuis 1985) les migrations et l'aide alimentaire ont dû être utilisées pour sauver les vies humaines. La sur-exploitation a aussi causé une plus grande dégradation.

La réhabilitation hydrologique de la plaine inondable du Logone a été étudiée par le Projet du Logone Waza. Sur la base des connaissances actuelles les mesures suivantes pourraient être prises: l'ouverture des digues du Logone afin de joindre de nouveau la plaine inondable au fleuve; le déversement contrôlé des eaux du lac Maga, associé à une augmentation du débit du Logone au lac Maga; et peut-être la réhabilitation des cours d'eau et des canaux qui transportaient jadis l'eau sur la plaine.

Gestion des ressources en eau dans le delta du fleuve Indus, Pakistan

PETER-JOHN MEYNELL ET M. TAHIR QURESHI

Au cours des quarante dernières années les eaux de l'Indus ont été progressivement contenues et détournées pour l'irrigation, la production d'électricité et l'approvisionnement en eau industriel et domestique. À l'origine le débit annuel moyen de l'Indus était d'environ 150 millions de pied acres (MAF), dont environ 105 MAF (c'est-à-dire 5,850 m^{3}sec^{-1}) sont retenus chaque année à l'heure actuelle, et environ 35 MAF sont déversés dans le fleuve à partir du barrage inférieur. Seulement 20 MAF environ gagnent le delta et, pendant neuf mois de l'année, l'eau douce ne s'écoule pas. De récents accords sur la répartition de l'eau entre les provinces du Pakistan ont reconnu qu'un minimum de 10 MAF devraient être déversés dans le delta pour des raisons environnementales. L'irrigation, pratiquée sans mesures de drainage suffisantes, a conduit à la disparition de terres agricoles en raison de la saturation du sol par l'eau et de la formation de sols hypersalins. Environ la moitié de l'eau détournée pour les besoins de l'irrigation est perdue avant même d'atteindre les champs en raison de l'infiltration, de l'évaporation et de l'inéfficacité des méthodes employées. Le problème de l'intrusion saline, du delta vers les eaux souterraines, devient très sérieux dans le Bas-Indus. Une réduction progressive du débit de l'eau douce a un effet sur la salinité des cours d'eau du delta (la salinité dépassant souvent 45 ppm [parties par milliers]). Ceci a une incidence sur la mangrove, avec retardement de la croissance et perte des plantules. La survie de l'écosystème des mangroves est menacée.

De plus, la réduction du limon déversé, de 400 millions de tonnes par an à moins de 100 millions de tonnes à l'heure actuelle – et sans doute moins encore à l'avenir – a des répercussions sur la géomorphologie du delta. Conjugué à une augmentation du niveau de la mer, le delta devrait éventuellement s'aplanir et s'éroder, offrant ainsi une protection moindre contre la violence de la mousson du sud-ouest. En raison de la réduction des sédiments terrestres les mangroves ne pourront supporter d'autres augmentations du niveau de la mer. Dû à la pression démographique croissante, il est peu probable que de plus grandes quantités d'eau douce et de boue soient, à l'avenir, déversées dans l'Indus. Des mesures de gestion pourraient inclure le reboisement avec des espèces de mangrove plus résistantes au sel et le déversement d'eaux de drainage agricole légèrement salines.

Protection de la Forêt de Marécages Tourbeux du Nord Sélangor, Malaisie

NATHER KHAN

Les sols tourbeux occupent une superficie d'environ 809,000 hectares, représentant environ 6% de la superficie totale des sols de la péninsule malaise. À l'origine les forêts couvraient sans doute la totalité de la région; il ne restait cependant que 497,276 hectares de forêts en 1954. La grande majorité de cette forêt de marécages tourbeux a été défrichée pour les besoins de l'agriculture et l'extraction de l'étain. De plus, les forêts naturelles des terres tourbeuses ont été exploitées commercialement pendant plus de 40 ans pour la production de bois de construction. Ces pressions répétées ont conduit à une diminution rapide de la forêt primaire et à une dégradation de ses ressources naturelles et de son rôle, en tant que zone humide, en particulier pour l'hydrologie et les ressources en eau.

La Forêt de Marécages Tourbeux du Nord Sélangor, qui couvre une superficie de 75,000 hectares, est située le long de la bordure orientale du Projet de Développement Agricole Intégré du Nord-ouest Sélangor, l'une des plus importantes zones de riziculture de Malaisie. La forêt de marécages est reconnue comme étant le plus important marécage tourbeux de la 'côte ouest' de Malaisie et est d'une importance considérable, au niveau national et international. Elle a été également identifiée comme l'une des trois zones humides prioritaires de la péninsule malaise pour l'application de plans de gestion. Le marécage joue également un rôle important dans la régulation des crues et le contrôle de la pollution. Le dégagement ou le drainage de cette forêt de marécages tourbeux pourraient mettre fin, entre autres, à son rôle temporaire d'emmagasinement des eaux dont bénéficie le système d'irrigation, augmenter les crues et la charge de sédiments, modifier la qualité de l'eau et accélérer l'intrusion saline dans les zones situées en amont et dans les projets de riziculture.

Aires protégées et barrages: le cas du delta du fleuve Sénégal

PIERRE POL VINCKE ET IBRAHIM THIAW

D'importants projets hydrologiques ont été entrepris sur le Sénégal. Deux barrages y ont été construits: l'un, antisel, à Diama, près de l'embouchure du fleuve, et l'autre, hydroélectrique, à Manantali, au Mali.

Le développement de la sous-région va dépendre du succès de ces ouvrages. Des études menées dans le cadre de cet important projet de développement ont, une fois encore, soulevé le problème des aires protégées et de leur intégration dans de tels projets. Les études ont montré que leur avenir dépendra, avant tout, de la capacité des gouvernements à les intégrer dans leur planification, à définir une politique de développement basée sur une gestion optimale des ressources naturelles de leur pays (existant également en dehors de ces zones), à maintenir un climat fructueux de coopération régionale et il dépendra aussi de la réaction de leurs partenaires internationaux vis-à-vis de ces projets.

Des exemples choisis sur la rive droite (Mauritanie) et la rive gauche (Sénégal) du delta du Sénégal illustrent à la fois la situation d'ensemble de l'environnement naturel du bassin et la politique environnementale appliquée – ou ignorée – par les gouvernements concernés.

Systèmes traditionnels d'utilisation des eaux et leur rôle dans la gestion des aires protégées

WILLIAM M. ADAMS

La gestion des zones humides protégées dans les pays industrialisés et en développement souligne l'importance de systèmes établis permettant de pouvoir comprendre, prendre modèle et gérer les ressources en eau. Dans les pays du tiers-monde, les systèmes indigènes d'utilisation des ressources en eau offrent une autre approche pour la gestion des zones humides. La consommation indigène d'eau comprend la pêche, le pastoralisme saisonnier et l'agriculture. L'agriculture des zones humides peut varier des cultures sur plaine inondable (par exemple le riz) et des cultures de décrue aux systèmes d'irrigation d'importance variée. Cet article décrit la nature de l'utilisation économique humaine des zones humides et les systèmes et l'importance de l'utilisation indigène des ressource en eau. Il traite en particulier des plaines inondables des zones humides des régions tropicals semi-arides. L'article examine les intérêts communs aux populations autochtones utilisant les zones humides et aux systèmes de gestion des aires protégées. Il soutient que la gestion indigène des zones humides et les zones humides protégées exigent le maintien des systèmes hydrologiques et des écosystèmes qu'ils supportent. Les systèmes indigènes d'utilisation des ressources des zones humides sont souvent durables et compatibles avec les nombreux objectifs de gestion des aires protégées, en particulier dans les zones tampon. Les populations et les aires protégées des zones humides dépendent tout ausi des décisions politiques concernant la gestion des systèmes hydrologiques et des bassins fluviaux. La valeur économique des systèmes de production indigènes peut être utilisée, lors de débats sur le développement des bassins fluviaux, comme un argument puissant en faveur de la gestion durable des systèmes hydrologiques.

Advertisements

Camera-ready copy only.
Full page (208×138 mm) £240;
half page (100×138 mm) £138;
quarter page (NB 48×138 mm) £80.

Black and white reproduction of photos charged at £10 extra each.

Further details available from the PARKS office (see inside front cover).

Subscribing to PARKS

Each Volume of **PARKS** consists of three issues, published in February, June and October. **PARKS** is produced and managed on behalf of CNPPA by the Nature Conservation Bureau Ltd. ISSN: 0960-233X. Subscriptions are £18 plus postage per volume; reduced rate of £12 plus postage per volume for 10 or more copies of that volume delivered to a single address.

Each issue of PARKS addresses a particular theme:

Vol. 5 no. 1: Parks and Information Technology
Vol. 5 no. 2: Managing Water Resources
Vol. 5 no. 3: Organisations and Institutions: the way forward

PARKS is the leading global forum for information on issues relating to protected area establishment and management

PARKS puts protected areas at the forefront of contemporary environmental issues, such as biodiversity conservation and ecologically sustainable development.

PARKS is published by the Commission on National Parks and Protected Areas (CNPPA) of IUCN – The World Conservation Union. **PARKS** aims to strengthen international collaboration among protected area professionals and to enhance their role, status and activities.

The following back issues are available at £7.10 (UK), £7.50 (Europe) or £8.80 (rest of world) each: Vol. 4 no. 2 (Financing Protected Areas) and no. 3 (Sustainable Development – Making it Work). No other back issues are available.

Order form/Invoice proforma

Return to: PARKS, 36 Kingfisher Court, Hambridge Road, Newbury, RG14 5SJ, UK. Each subscription lasts for a year (three issues), and includes postage and packing. There is a reduced rate for multiple subscriptions.

Please enter _____ subscription/s to PARKS, Vol. 5 (1995).

1–9 subscriptions:

- ☐ **UK:** **£21.30 each**
- ☐ **Europe:** **£22.60 each**
- ☐ **Rest of world:** **£26.40 each**

10+ subscriptions to a single address:

- ☐ **UK:** **£15.30 each**
- ☐ **Europe:** **£16.60 each**
- ☐ **Rest of world:** **£20.40 each**

☐ I enclose a cheque/money order for £ sterling made payable to The Nature Conservation Bureau Ltd.

☐ I wish to pay by Visa/Mastercard, please charge to my account no.

☐☐☐☐ ☐☐☐☐ ☐☐☐☐ ☐☐☐☐

Expiry date ____________

Name on card ____________

Signature ____________

Delivery address: (please print clearly)

Name ____________

Organisation ____________

Address ____________

____

____

Post/Zip Code ____________ Country ____________